Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

JULY, 1949

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WEAN

SPECIALISTS IN SHEET, TIN AND STRIP MILL EQUIPMENT

NARROW STRIP WIRE MILL AND STRAIGHTENING MACHINERY

The WEAN ENGINEERING CO., INC.
WARREN, O.

WEAN EQUIPMENT CORP.
CLEVELAND, O.

R v.26 July-Dec. 1949

EVERY TYPE OF OPERATOR

Plain Button Base Mounting | Plain Button One Hole Mounting | Maintained Contact Base Mounting | Latch Down Plain Button | Mushroom Head Base Mounting | Mushroom Head One Hole Mounting | Rotary Selector 2 or 3 Position | Maintained Contact One Hole Mounting | Oil-Tight One Hole Mounting | Indicating Light One Hole Mounting | Latch Safe Base Mounting

EVERY TYPE OF STATION

General Purpose | Oil Tight | Flush Mounting | Water and Dust Tight | Oil immersed, Hazardous Class I and II

EVERY TYPE OF CIRCUIT COMBINATION...32 IN ALL

The Cutler-Hammer line of heavy duty pushbuttons offers the widest selection, by far, of operators, elements, stations and circuit combinations. This line has the unique distinction of being designed and engineered from the very start for such broad coverage of needs . . . through the development of a fundamentally correct contact mechanism capable of being incorporated into diversified types of elements, an equally modern and extensive line of operators . . . and a maximum number of circuit combinations.

As a result, users have gained such advantages as: complete interchangeability, uniformity of design and performance, exceptionally long life, frequently the elimination of any need for additional relays, interlocks and the like, ease of installation through visible contacts which facilitate circuit identification and terminals which are unusually large and accessible, and attractive appearance. All basic elements have successfully undergone Underwriters' tests. Here is a line attractive to machine designers, machine buyers and maintenance men alike. CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

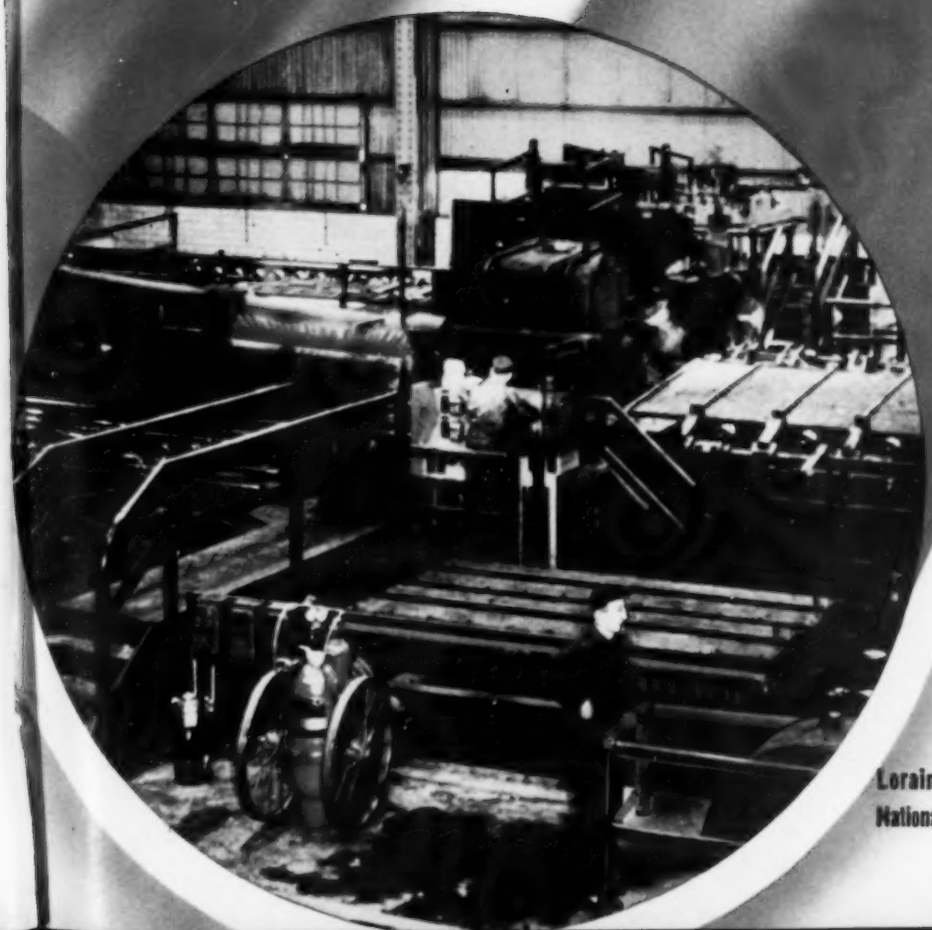
CUTLER-HAMMER
MOTOR CONTROL
C-H

IRON AND STEEL ENGINEER, published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress March 3, 1879. $7.50 per year in United States and Canada, $10.00 foreign countries. Volume 26, No. 7.

CRAFTSMEN IN *Piercing Mills*

When you consider a capital expenditure for a piercing mill or a complete seamless tube mill, call upon us. We have the facts, the figures and the experience in tubular equipment. Aetna-Standard builds most of the piercing mills and seamless tube mills. Sizes range from 2½" to 15" in piercing mills and up to 26" O. D. in seamless mills.

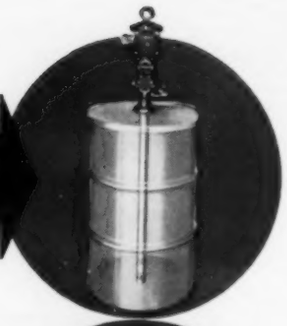
THE AETNA-STANDARD ENGINEERING COMPANY
YOUNGSTOWN, OHIO
ASSOCIATED COMPANIES:
HEAD, WRIGHTSON & COMPANY, LTD., THORNABY-ON-TEES, ENGLAND
AETNA-STANDARD ENGINEERING COMPANY, LTD., TORONTO, ONTARIO, CANADA



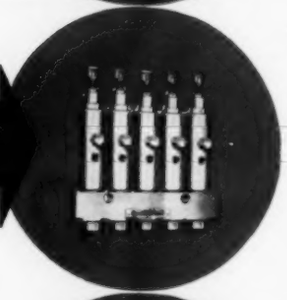
Lorain Works
National Tube Company

Standardize Lubrication Practices

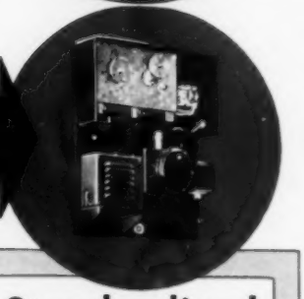
APPLY THE RIGHT LUBRICANT



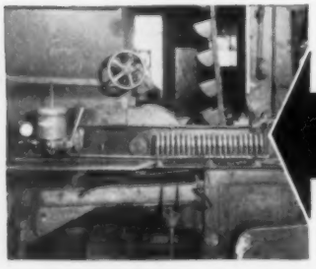
IN THE RIGHT QUANTITY



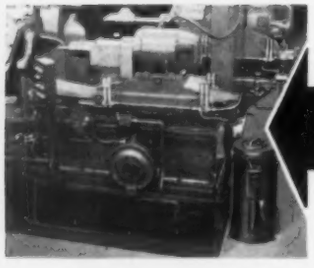
AT THE RIGHT TIME



Convert obsolete methods to Centralized Lubrication Circuits



MANUALLY OPERATED



INDIVIDUALLY POWER DRIVEN

COMPLETE MASS LUBRICATION with LINCOLN *Standardized* Lubricating Systems

Install Lincoln Standardized Lubricating Systems

Call your Lincoln Distributor or the Sales and Service office nearest you for expert advice on standardizing your lubrication practices. Ask for copies of Bulletins on Centro-Matic Systems and Industrial Catalog No. 63.

SALES AND SERVICE OFFICES:

BOSTON—H. G. Davis, Inc.—Kenmore 5176
BRIDGEPORT—H. G. Davis, Inc.—Bridgeport 5-8160
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B48-21

PIONEER BUILDERS

LINCOLN ST. LOUIS

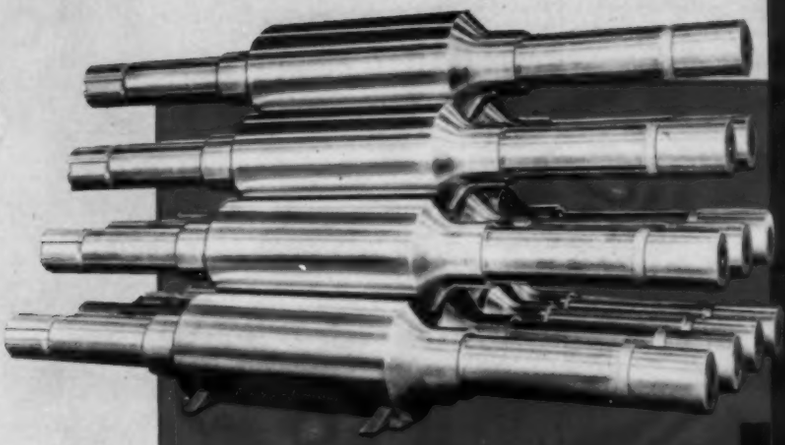
LUBRICATING EQUIPMENT

LINCOLN ENGINEERING COMPANY • 5733 NATURAL BRIDGE AVE., ST. LOUIS 20, MO.

Rolls and Pinions

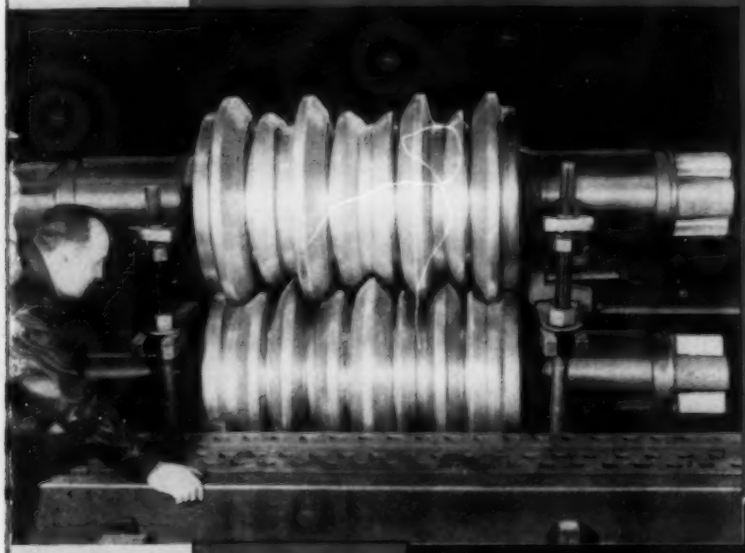
Designed and Built by

MESTA

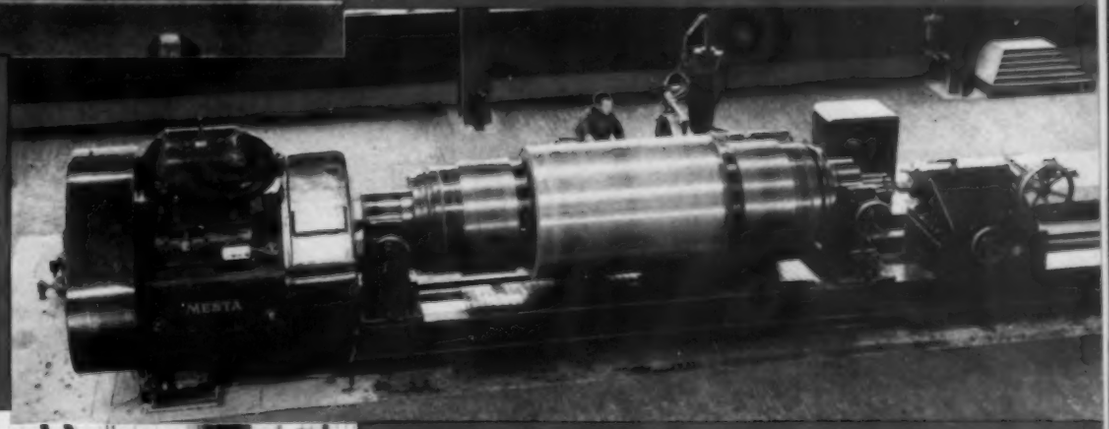


Group of Forged Hardened Electric Steel Working Rolls for Cold Reduction Mills

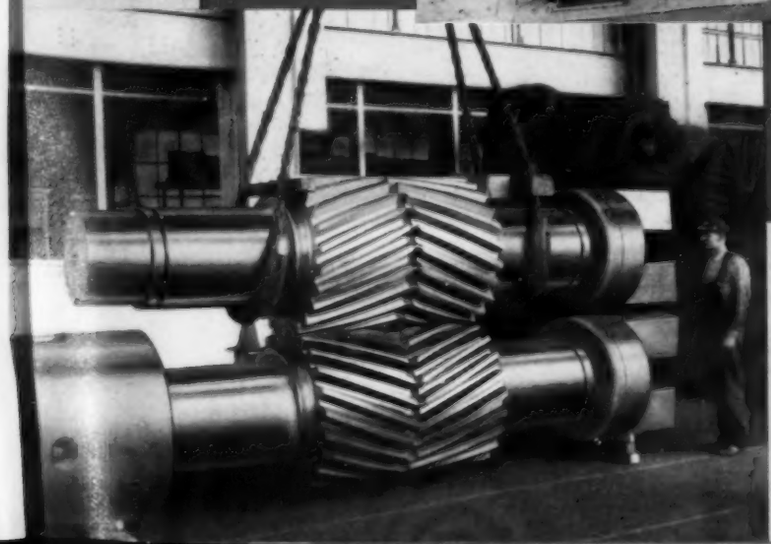
A pair of Mesta Merchant Mill Rolls for the production of I-Beams



Mesta 56" diameter Special Alloy Cast Steel Backing-Up Roll for a modern high speed Four-High Cold Reduction Mill



Mesta 60" Heavy Duty Traveling Wheel Head Type Roll Grinder

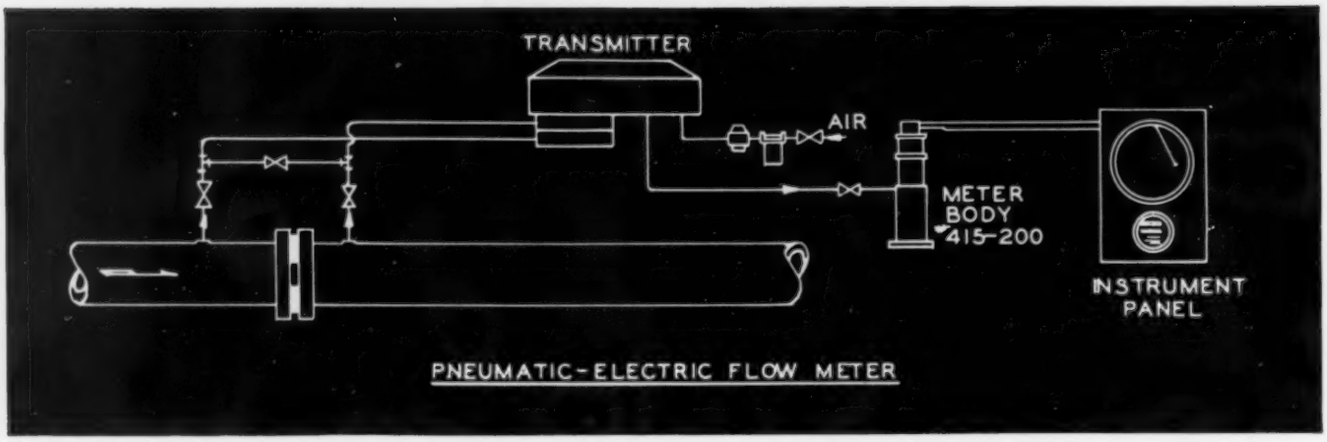


38" x 54" Forged Steel Blooming Mill Pinions
Mesta also produces Cast Steel Mill Pinions with cut or molded teeth

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PA.



The Answer to Your **OXYGEN** *Metering Problems!*

Here is an oxygen flow metering system that will accurately integrate the rapidly fluctuating flows encountered in steel mill operations.

CONTINUOUS INTEGRATION

The electric integrator, operating on a modified watt hour principle, is continuous, not intermittent in operation — is extremely sensitive, acceleration and retardation being practically instantaneous. It will accurately integrate the most erratic fluctuations transmitted by the highly responsive meter element.

SENSITIVE METERING SYSTEM

The flow metering system, shown diagrammatically above, is a combination pneumatic-electric system for measuring a rapidly fluctuating flow. It consists of a pneumatic transmitter, an electric meter body and any desired combination of remote reading instruments. It has been especially designed to overcome the problems encountered in oxygen flow measurement.

FIELD TESTS

Laboratory tests of the complete meter have shown an over-all accuracy within ±2% for various flow cycles, including a cycle as short as 8 seconds "on" and 8 seconds "off". Field installations checked against weighed quantity of oxygen actually delivered over six month period substantiate these laboratory tests.

WIDE RANGE

For those installations where wide ranges of flow are encountered, a Republic pneumatic-electric metering system can be installed with a range of approximately 10 to 1. By a special piping arrangement, the range of accurate flow measurement can be extended to approximately 50 to 1.

Republic Continuous Integrator

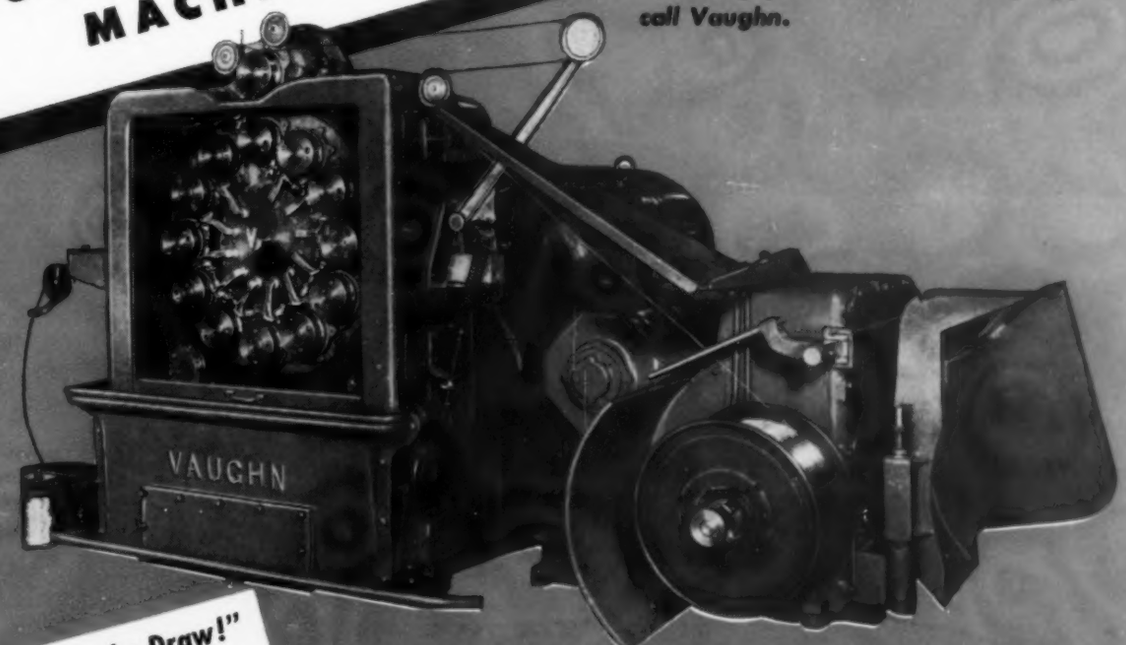
The Republic pneumatic-electric flow metering system is completely described in Bulletin No. 48-2.

Write for your copy today.

REPUBLIC FLOW METERS CO.
2240 Diversey Parkway, Chicago 47, Illinois

with Vaughn COLD DRAWING MACHINERY

Vaughn Cold Drawing Machinery thrives on long, hard runs because we build tough *production-ability* into each and every unit. Vaughn flexibility and versatility take care of the short runs, too! For cold facts on cold drawing problems of every type, *call Vaughn.*



"Quick on the Draw!"
VAUGHN MACHINERY
PROFITABLY USED BY LEADING WIRE MILLS SINCE 1871

THE VAUGHN MACHINERY COMPANY

CUYAHOGA FALLS, OHIO, U. S. A.

COMPLETE COLD DRAWING EQUIPMENT—Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.

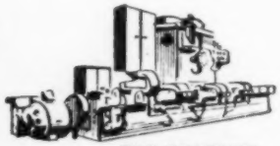
Still more Bonnot Billeteers are on the way to Europe to join those already speeding steel production for industrial recovery. Plants receiving the new Billeteers in the near future are located in Belgium, Luxemburg, Italy and France.

World-wide acclaim for the Billeteer lies in what the Billeteer is doing for every plant in which it is installed. The billet shed was once the bottleneck between furnaces and shipping docks. Today with Bonnot Billeteers, deep flaws can be cut out and remelting of billets is practically eliminated—there's a steady flow of clean billets to finishing mills. Operating records show a Billeteer handling 100 tons of billets per shift—removing up to 1½ tons of steel scrap—all flaws completely eliminated—all chips 100% reclaimable.

Just one operator handles the Billeteers easily during an 8-hour shift, doing the work of more than 10 hand chippers and without the fatigue and manpower turnover that results from more muscular methods of billet cleaning. Why not let the Bonnot Billeteer work for you? Write for information today!

Engineered for Improved Production

The Bonnot Co.
STEEL EQUIPMENT DIVISION
CANTON 2, OHIO



THE BILLETEER

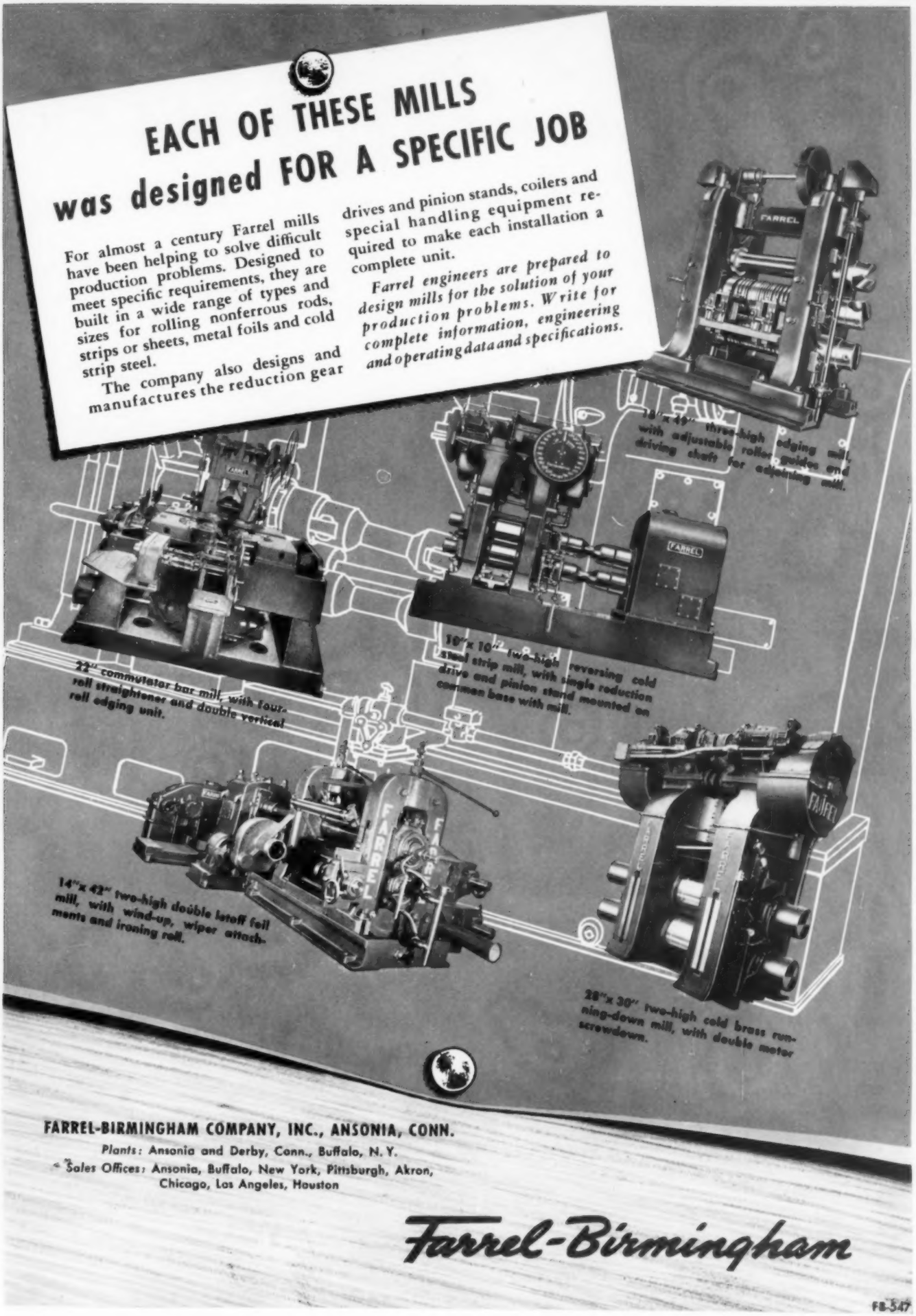
ALSO MANUFACTURERS OF SAWING · CRUSHING · PULVERIZING & MIXING EQUIPMENT

EACH OF THESE MILLS was designed FOR A SPECIFIC JOB

For almost a century Farrel mills have been helping to solve difficult production problems. Designed to meet specific requirements, they are built in a wide range of types and sizes for rolling nonferrous rods, strips or sheets, metal foils and cold strip steel.

The company also designs and manufactures the reduction gear drives and pinion stands, coilers and special handling equipment required to make each installation a complete unit.

Farrel engineers are prepared to design mills for the solution of your production problems. Write for complete information, engineering and operating data and specifications.


FARREL
22" commutator bar mill, with four-roll straightener and double vertical roll edging unit.
10" x 10" two-high reversing cold steel strip mill, with single reduction drive and pinion stand mounted on common base with mill.
14" x 42" two-high double lstoff foil mill, with wind-up, wiper attachments and ironing roll.
28" x 30" two-high cold brass running-down mill, with double motor screwdown.

FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN.

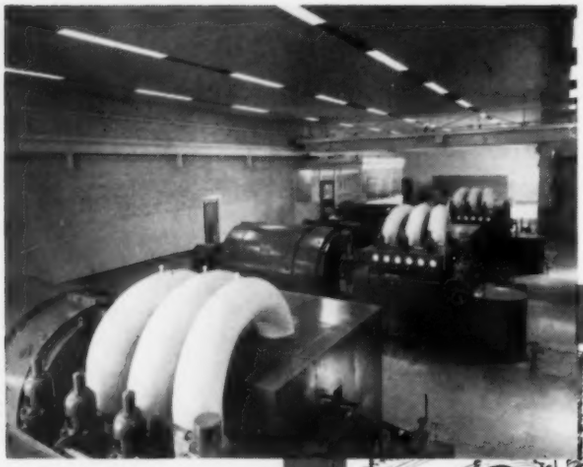
Plants: Ansonia and Derby, Conn., Buffalo, N. Y.

Sales Offices: Ansonia, Buffalo, New York, Pittsburgh, Akron, Chicago, Los Angeles, Houston

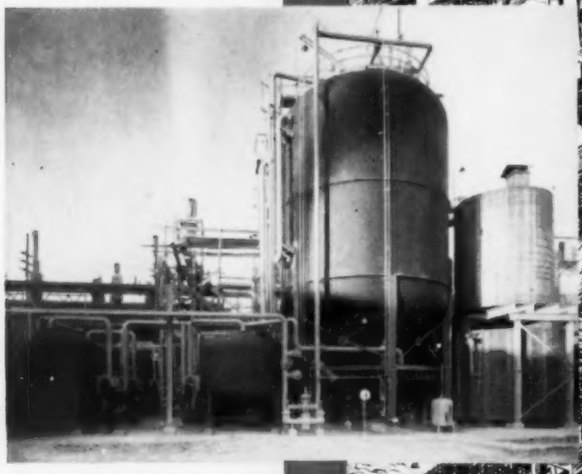
Farrel-Birmingham

FB-547

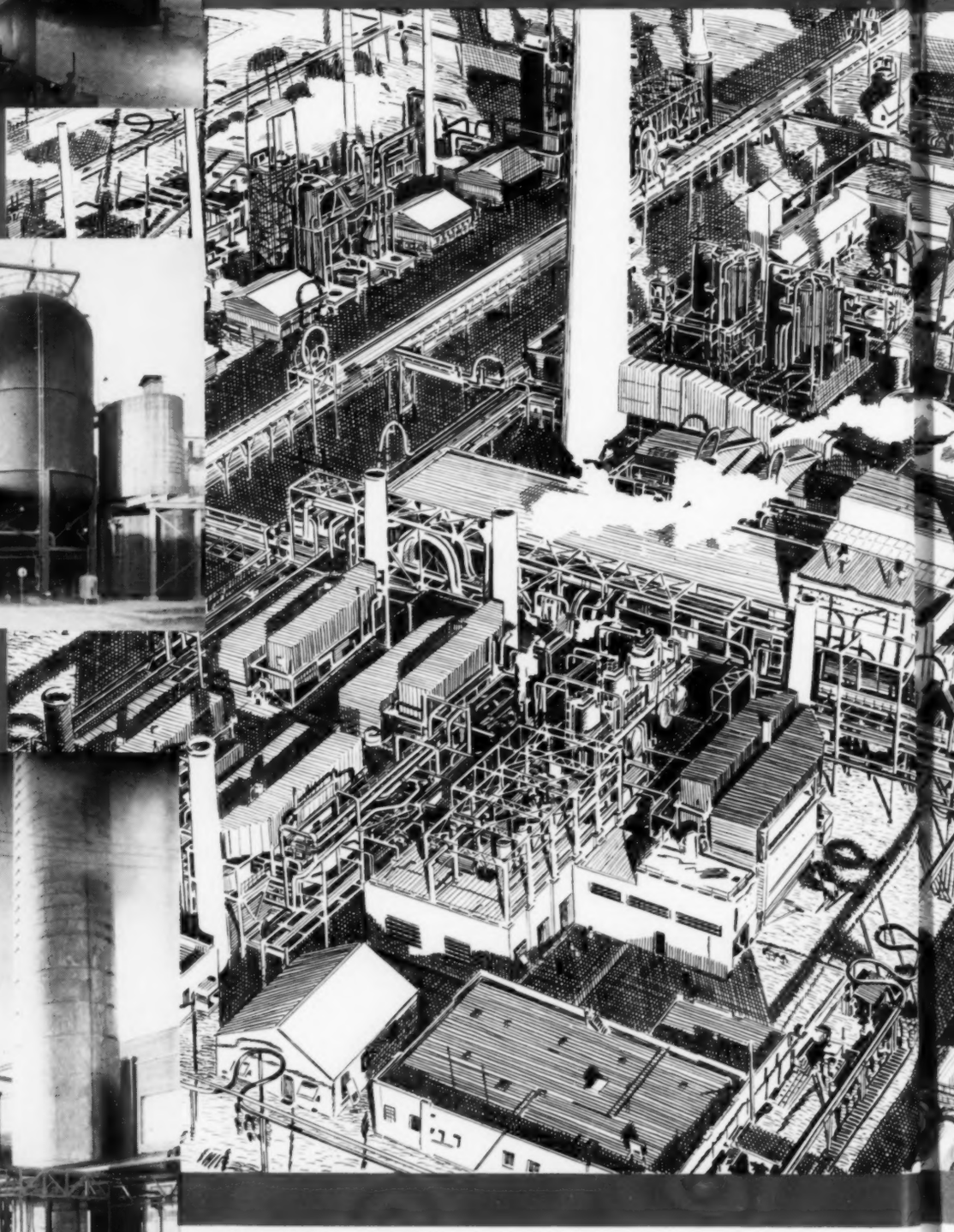
SPECIAL



View inside the power station, showing the three new 10,000-kw turbine generators.



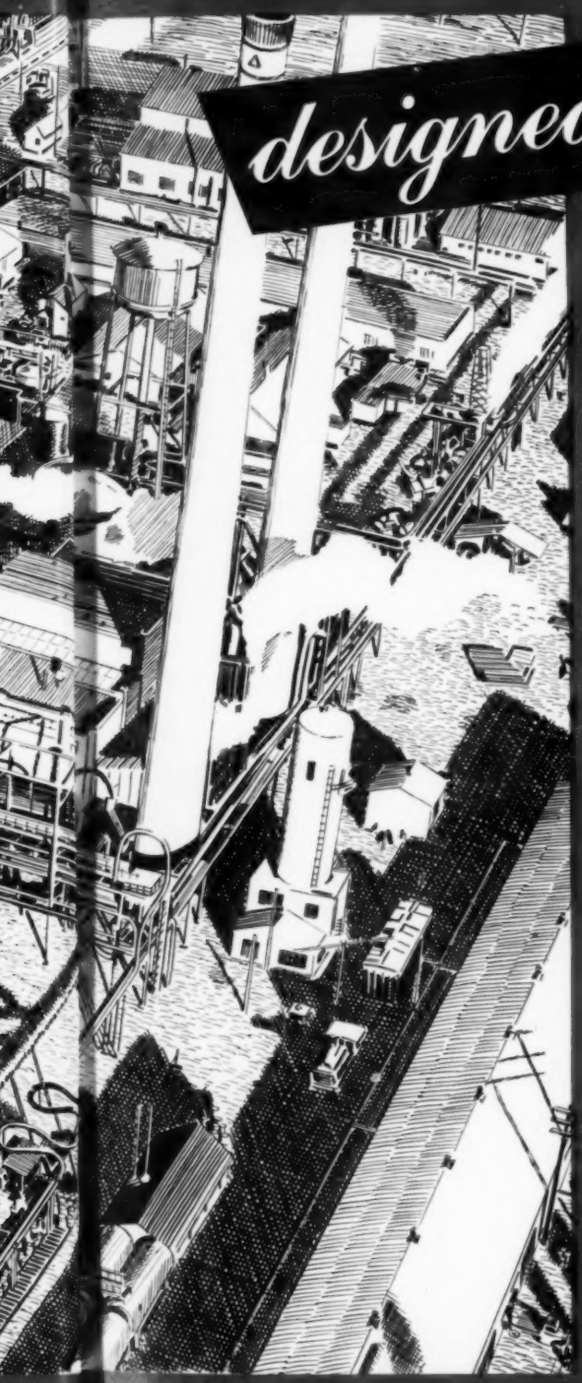
This is the water-treating plant.



Facilities for handling lime for water treatment.

L POWER PLANT

designed and built by Fluor



499

Use of Exhaust Steam for Process Involves High Backpressure and 90% Water Make-up

A complete power plant of 30,000-kw capacity was designed and built by Fluor for this Texas refinery of a leading oil company.

To supply processes in the refinery with steam at 200 psig, and to provide the required electric power, five 250,000 lb/hr, 650 psig working pressure boilers and three non-condensing, 650 psig input, 200 psig exhaust, 10,000-kw turbine generators were installed. Because of the nature of the operation, only about 10% of the condensate can be economically returned to the boilers. Make-up water constitutes 90% of the water supply. Hence, ample facilities for water treating, deaerating, and lime handling were provided. Details of this interesting and successful power plant are available on request.

now is the time Your new plant facilities may be more profitable to build today, because Fluor's present engineering and construction costs are substantially lower. Let us tell you why *Now is the time.*

MEMBER OIL, STEEL, CHEMICAL, FLUOR

BE SURE WITH FLUOR

FLUOR

THE FLUOR CORPORATION, LTD., Los Angeles 22

NEW YORK
PITTSBURGH
TULSA
CHICAGO
HOUSTON
BOSTON
SAN FRANCISCO

Johns-Manville

Announces...

...sets a new high of 3000 F for insulating fire brick service

● Here is a new insulating fire brick, especially developed by the Johns-Manville Research Laboratory for use in forge furnaces, ceramic kilns, chemical process furnaces and other types of high-temperature equipment operating above the previous range of insulating fire brick.

Some of the more outstanding advantages of JM-3000 Insulating Fire Brick are: It is the highest temperature insulating fire brick made for backup or exposed use, effectively withstanding the full 3000 F. Its efficiency remains at a high level throughout the life of the brick. It has exceptional service advantages in many operations at lower temperatures where regular or special fire brick is ordinarily used.

With its combination of outstanding insulating and refractory properties, JM-3000 Insulating Fire Brick has been found to provide longer life, greater fuel economy and important savings in downtime. For further information, write to Johns-Manville, Box 290, New York 16, N. Y.

PHYSICAL AND THERMAL PROPERTIES

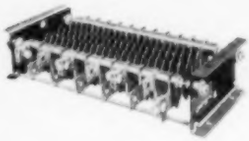
Molded from high quality kaolin clays plus alumina
Density—63-67 lb per cu ft
Modulus of rupture—200 lb per sq in.
Linear shrinkage—(24 hr Panel test @ 3000 F) .8 per cent
Linear thermal expansion to 2000 F—.5 to .6 per cent
Pyrometric cone equiv.—Cone 37+ (3308 F+)
Temperature limit—3000 F

Conductivity (Btu in. per sq ft per F per hr at mean temp)

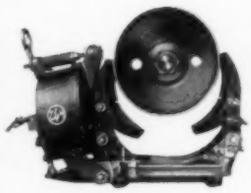
F	500	1000	1500	2000
Btu	3.10	3.20	3.35	3.60

Johns-Manville *First in* INSULATIONS

Complete Control for Cranes



TAB - WELD Resistors — no burning where burning would cause high up-keep.



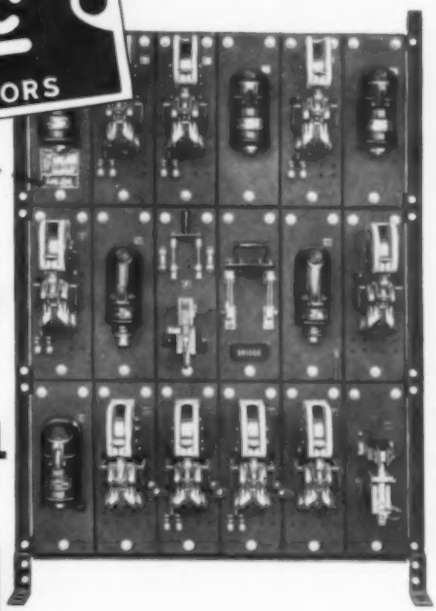
LONG-LIFE Brakes give high speed performance—with low up-keep.

SHORT-THROW, narrow-width Cam Master switches are easy on the operator.

TIME-CURRENT Relay matches acceleration to the d-c load.

WITH **LINE-ARC** (TRADE MARK REG.) CONTACTORS

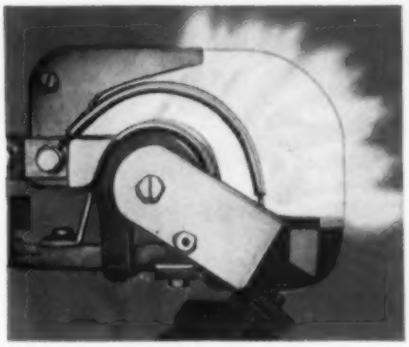
N. P. 168



A Good Reason

for specifying

EC&M CRANE CONTROL



1. Fast response permits quick crane movements.
2. Lower maintenance because there is no destructive burning.
3. Built in 2, 3, or 4 decks to suit mounting space.

The LINE-ARC Design - this EC&M Development— has earned a reputation among crane users

EC&M *LINE-ARC* Magnetic Contactors have a flexibility that makes them the logical choice for controlling cranes. They have no excess weight limiting quick response and penalizing output under normal conditions. Neither do they show distress when handling the occasional abnormal load which, experience shows, cannot always be avoided.

The *LINE-ARC* principle is always an asset. Contacts operate at a low temperature and have long life. Destructive arc-shield burning is eliminated because the arc is centered in a line between, but not touching, the arc shields. Look at the contactor fitted with special glass arc shields and rupturing 300% rated load. In repeated tests, the glass has been neither harmed nor smudged. Specify EC&M LINE-ARC Controllers.

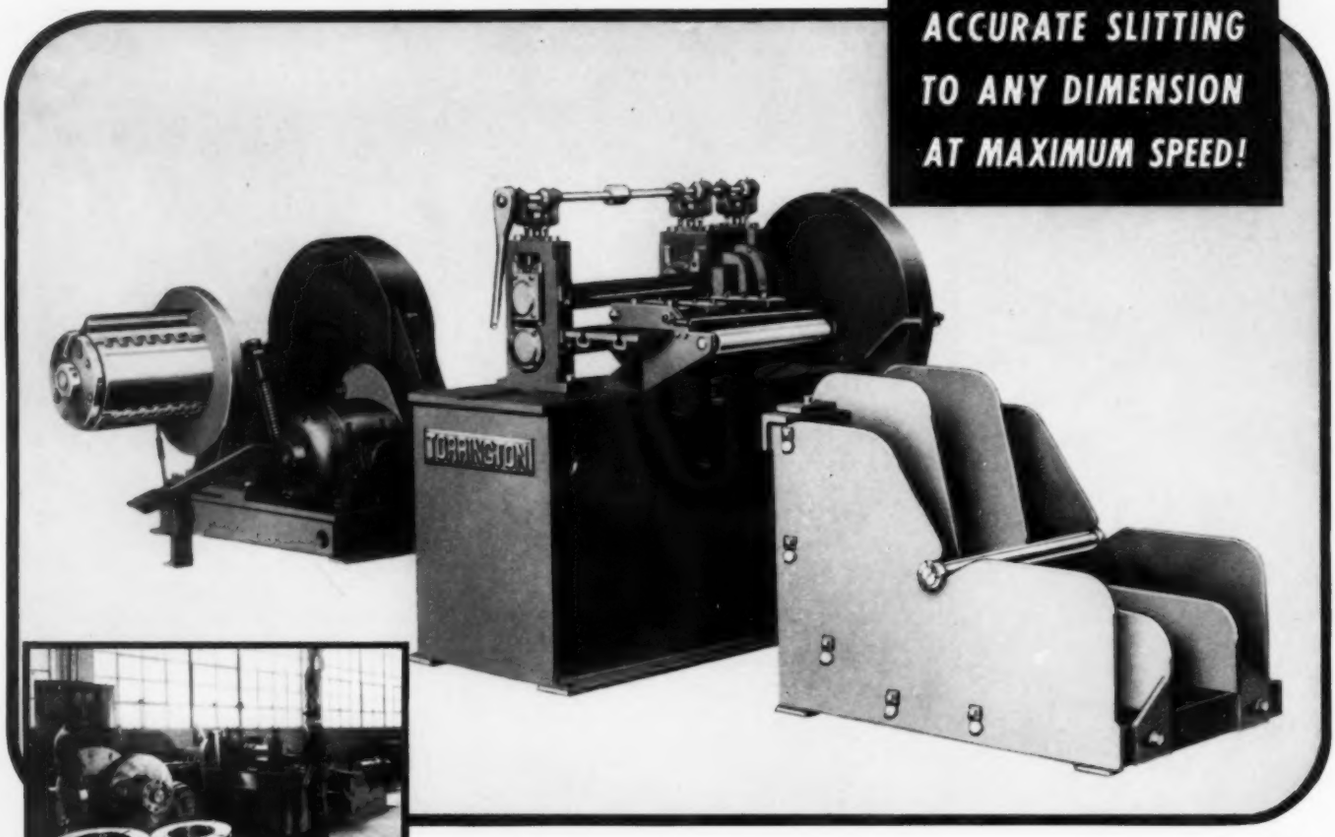
DUPLEX Youngstown Limit Stop.

CRANE DISCONNECT SWITCH Manual-magnetic for ease of operation.

THE ELECTRIC CONTROLLER & MFG. CO.

2698 EAST 79TH STREET • CLEVELAND 4, OHIO

ACCURATE SLITTING TO ANY DIMENSION AT MAXIMUM SPEED!



On the job in Bridgeport, Conn.

TORRINGTON'S *HIGH-SPEED* SLITTING LINE
Converts wide stock to any desired dimension!

★ Motor-driven slitter for threading up!

★ Winder with automatic collapsible block!

★ Arranged for pull-through operation!

★ Anti-friction bearings used throughout!

These compact, easily operated Torrington machines have been designed to meet the needs of users who require slitters which can be quickly set up and operated with minimum time and effort.

Here are just a few of your advantages with a Torrington Slitter on the job: 1. Ability to secure metals in wide widths quickly! 2. Elimination of large and unbalanced inventories of cut-to-width materials! 3. Quicker deliveries on shorter notice because of broader source of supply! 4. Instant availability of slitter to convert wide stock to any dimensions for daily production needs!

The sturdy construction of Torrington Slitters assures years of continuous, dependable service. With the proper tool set-up, you can hold widths within the limit of .001", plus or minus.

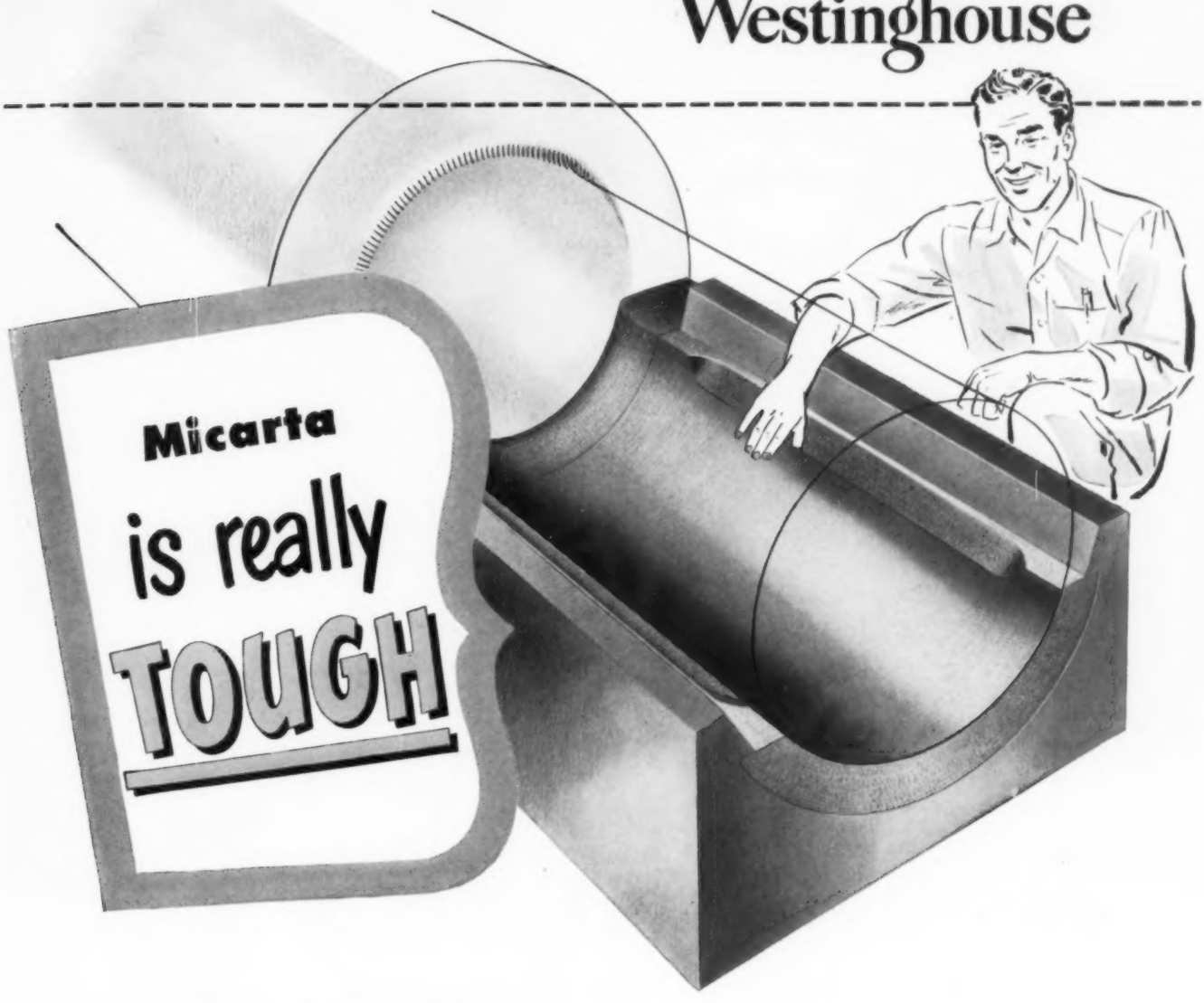
Call or write Torrington today for more information and name of nearest Torrington representative.

The TORRINGTON
MANUFACTURING COMPANY TORRINGTON, CONNECTICUT

DESIGNERS AND BUILDERS OF MILL MACHINERY FOR OVER 60 YEARS

YOU CAN BE **SURE**.. IF IT'S

Westinghouse



. . . wears 10 to 15 times longer—

Micarta bearings last longer—10 to 15 times longer than lignum vitae—up to 80 times longer than metals.

That's because Micarta is really tough . . . because it's resilient, smooth and self-polishing—because it exceeds the compressive strength of steel, pound for pound.

This slow rate of wear means increased tonnage through fewer shutdowns for replacement . . . fewer screwdown adjustments and test bars. Costs are cut through savings in replacement expense, and prevention of damage to rolls and roll necks.

Micarta also improves steel-plate quality. Better holding of gauge results from its dense, hard, wear-resisting qualities. Closer tolerances on rolling fine-gauge materials are obtained.

Micarta can improve operation, cut costs in other ways, too. For data and application help, call your nearby Westinghouse office. Ask for Book B-3776, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Penna. J-06423

Westinghouse Micarta

Do you have gears that look like this? Brooks "LEADOLENE" will gradually improve these gears so that they will "smooth-up" and definitely reduce the amount of wear.

BROOKS "I.P." LEADOLENE

FOR YOUR LUBRICATION PROBLEMS

on CIRCULATING OIL SYSTEMS and OPEN GEARS

Lubrication Dan (the Brooks Oil man) shows the points of excess wear on gears—the spots that cause production worries from pitting, cutting and excess wear. As these conditions increase—so increases the danger of costly breakdown.

In the Brooks files are many cases where the gears have been in much worse condition than shown above, yet when Brooks "LEADOLENE" was introduced into the system further wear was immediately stopped. While "LEADOLENE" cannot build up the lost metal, it forms an indestructible pH-ilm that cannot sludge or breakdown. "LEADOLENE" provides a pH-ilm safety factor of up to 35,000 pounds pressure per square inch against the normal load of ordinary mineral oils of 6000 pounds per square inch.

Water will not contaminate or affect "LEADOLENE", eliminating the need for centrifuging. In addition, "make-up" has proved negligible as compared with ordinary mineral oils. Brooks engineers will be glad to work with you on *any* lubrication problem. Write today.

*LEADOLENE—the "I.P. Lubricant" (Indestructible pH-ilm).

The Brooks Oil Co.

Pittsburgh 12, Pennsylvania
Cleveland, Ohio
Hamilton, Ontario

Warehouses: In Principal Industrial Cities

OVER 78 WAYS TO MAKE SURE CONDUITS STAY PUT!

O.Z. has 'em ...IN STOCK

When you need U-BOLTS for that conduit or cable clamping job, try O-Z.

WHY?

BECAUSE the O-Z line is *in stock*, ready for immediate shipment.

BECAUSE the stock O-Z line has over 78 sizes and types for conduits from ½" to 6". As just one example, you can get *three* bolt diameters, for 1", 1¼" or 1½" conduit. You can get O-Z U-BOLTS, from stock of Everdur, steel cadmium plated or steel hot-dip galvanized. They come with nuts and flat washers, with or without saddles. They provide for clamping to a ⅜" thick plate using nuts and washers on each leg.

BECAUSE O. Z. will manufacture U-BOLTS of any size or material to meet your specifications.

There are thousands of O-Z products designed to help you put power where you want it, and your O-Z Distributor is the man to see about them. Send for illustrated catalog.

and Remember!

THEY'RE O.K. IF THEY'RE O.Z.

O.Z. ELECTRICAL MANUFACTURING COMPANY, INC.

262 BOND STREET · BROOKLYN 2, N. Y.

CONDUIT FITTINGS
CABLE TERMINATORS
CAST IRON BOXES
GROUNDING DEVICES
SOLDERLESS CONNECTORS
POWER CONNECTORS

5060

*POUR POINT

Today, it is essential to use the best lubricants money can buy — for maximum efficiency . . . lowest operating cost. That's why more and more production machinery is being lubricated with Tycol oils and greases.

Whatever your lubricating need — for turbine, steam engine, mine car or tipple, textile mill, stationary Diesel or locomotive — there's a Tycol high quality oil or grease exactly suited to your specific need.

In developing this comprehensive line, Tycol subjects each individual oil and grease to rigid tests during manufacture. This control assures the required lubrication characteristics — *POUR POINT, viscosity, color, penetration, to name a few — for maximum performance of that particular product.

Let us show you the extra value in every measure of Tycol oil and grease. Write your nearest Tide Water Associated office today.

TYCOL
INDUSTRIAL LUBRICANTS

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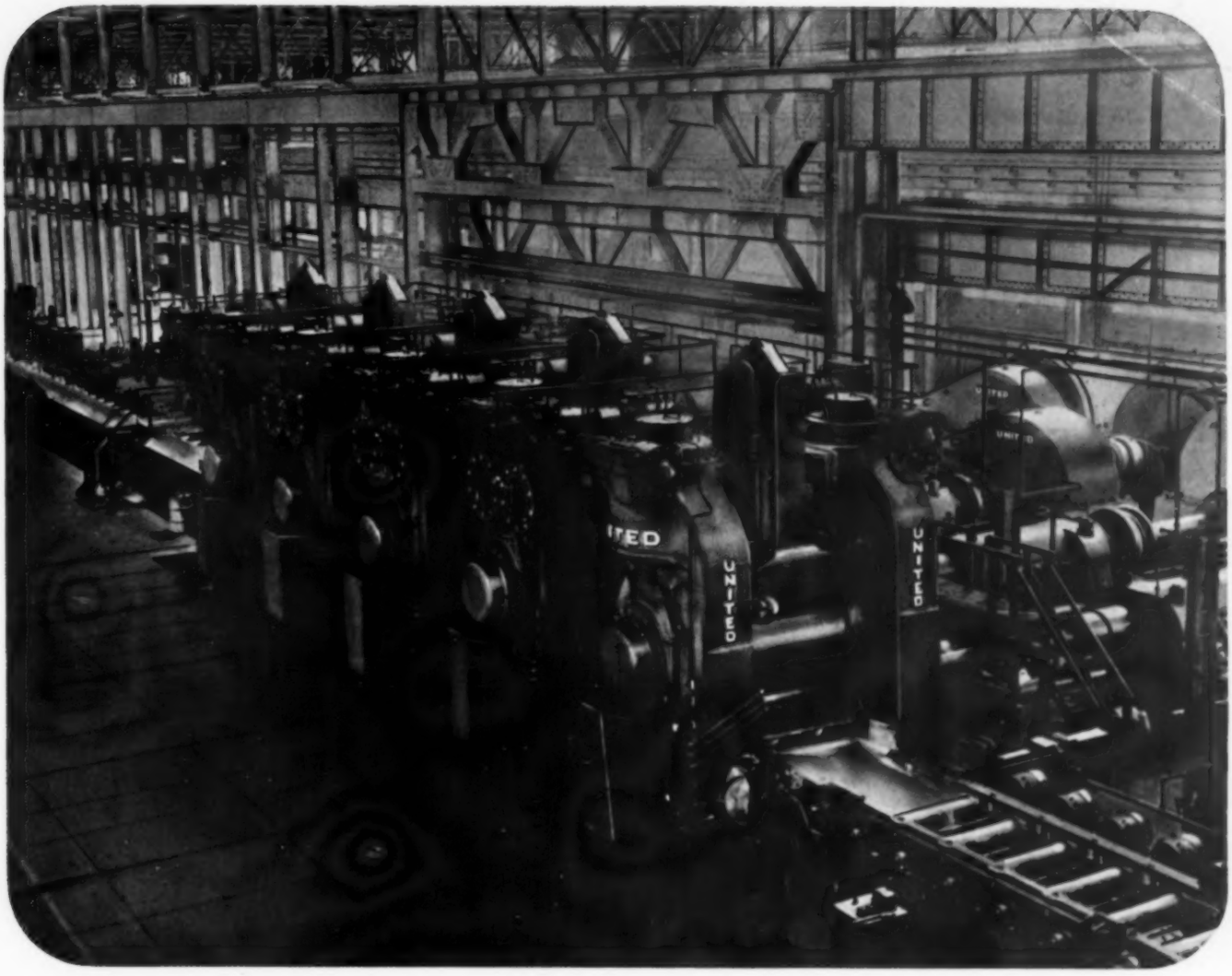
17 BATTERY PLACE · NEW YORK 4, N.Y.

*LEARN WHAT THIS PRODUCT CHARACTERISTIC MEANS TO YOU — READ "LUBRICANIA"
This informative handbook, "Tide Water Associated Lubricania," gives clear, concise descriptions of the basic tests used to determine important properties of oils and greases. For your free copy, write to Tide Water Associated Oil Company, 17 Battery Place, New York 4, N. Y.

REFINERS AND MARKETERS OF VEEDOL — THE WORLD'S MOST FAMOUS MOTOR OIL



Rolling aluminum on Continuous Hot Mill Finishing Stands for use in the fabrication of aircraft, modern railway rolling stock, domestic appliances, etc.

Designed and built by

UNITED ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

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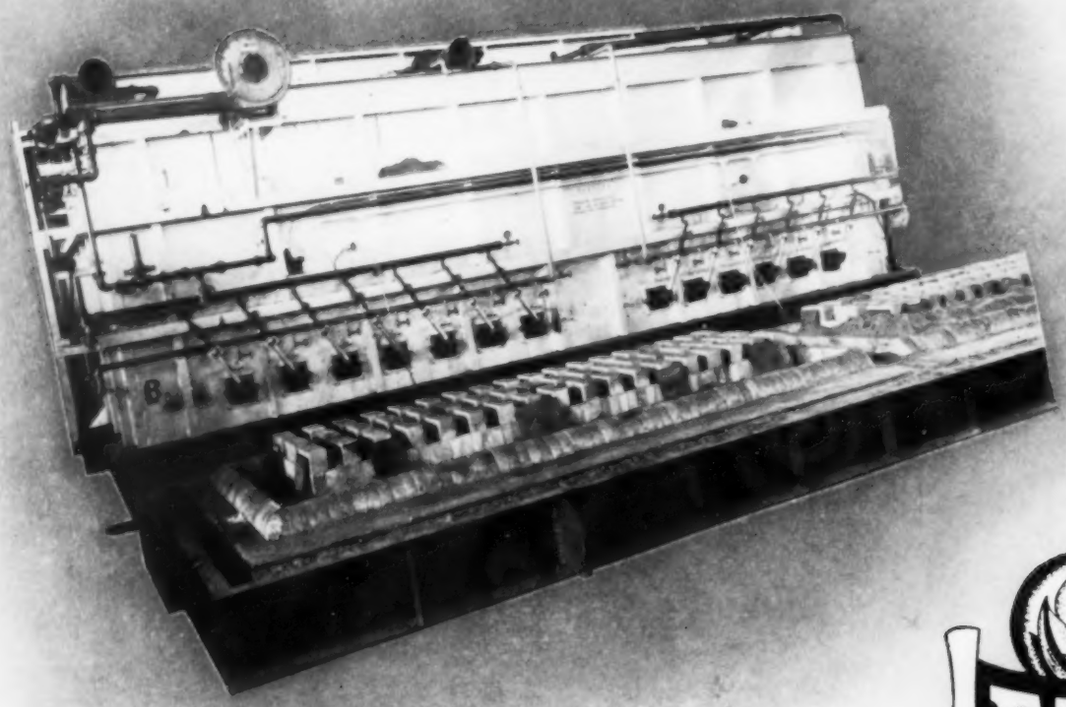
F.E.I. Patented Method of Heat Application For Maximum Low-Cost Production



Increased production at reduced unit costs has been the consistent result of F. E. I.'s Direct Fired Combustion System, which utilizes exclusive techniques of heat application in the metals producing field. Improved metallurgical quality accompanies enlarged output and lowered costs.

These principles, which have been proved in plant after plant, have been successful in Wire, Rod, Sheet, Strip, Bar and Galvanizing installations. For applicability of F. E. I. Direct Fired Combustion Systems to your present equipment, write, wire or phone for further information. Your request will not obligate you in any manner.

F.E.I. BUILDS:

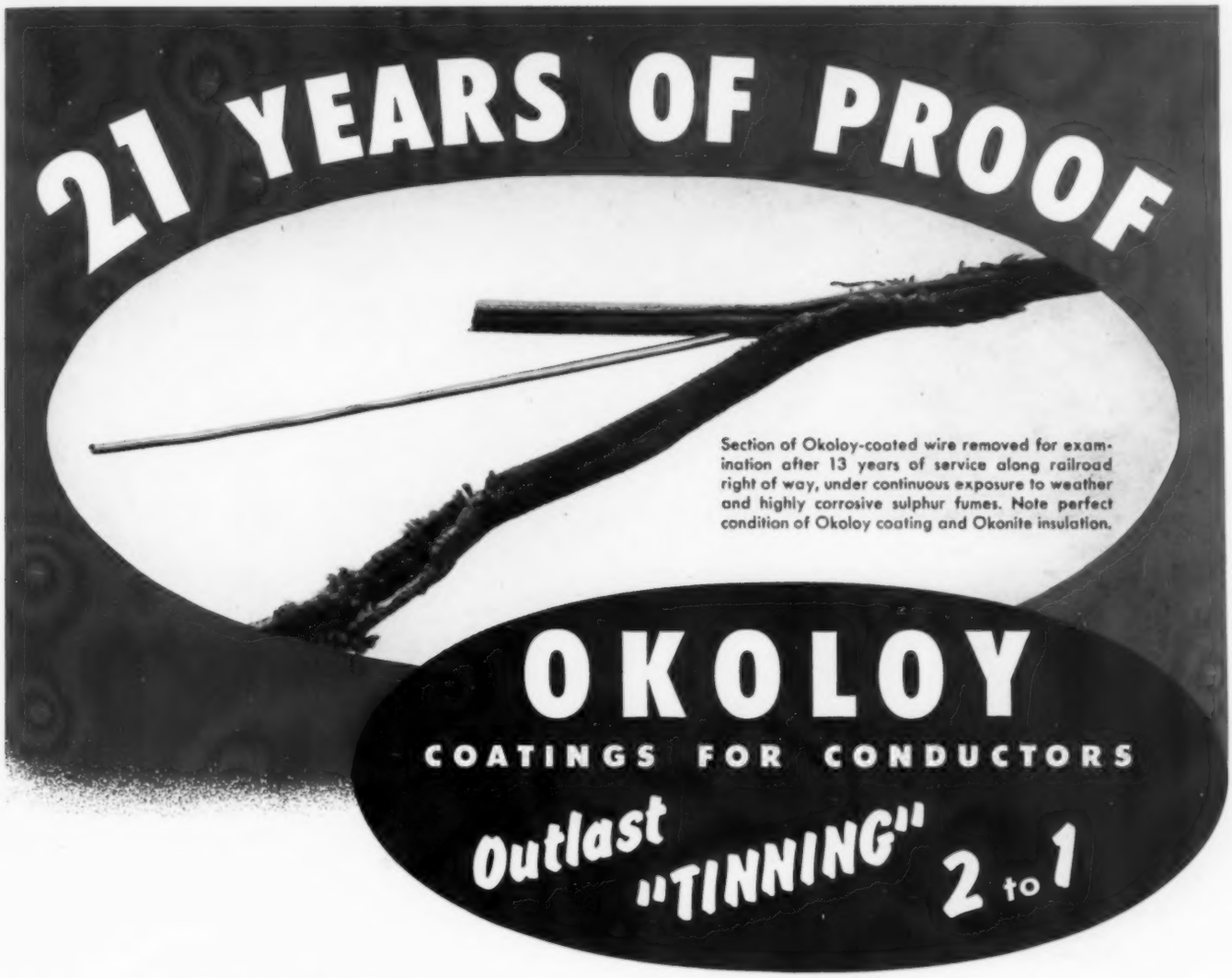
Open Hearth Furnaces; Soaking Pits, Continuous Bloom, Billet and Slab Heating Furnaces; Direct Fired Cover Furnaces for sheet and coil annealing; Salt Descaling Furnaces for stainless steel sheet, bar and other products; Heat Treating Furnaces for every use; Galvanizing Furnaces for tubes, sheet and metalware.

FURNACE ENGINEERS, *Inc.*

Representation In All Foreign Countries

1551 WEST LIBERTY AVENUE ★ PITTSBURGH, PA.

21 YEARS OF PROOF



Section of Okoloy-coated wire removed for examination after 13 years of service along railroad right of way, under continuous exposure to weather and highly corrosive sulphur fumes. Note perfect condition of Okoloy coating and Okonite insulation.

OKOLOY

COATINGS FOR CONDUCTORS

Outlast "TINNING" 2 to 1

. . . another reason why Okonite quality gives true cable economy!

TWENTY-ONE YEARS of repeated proof in severest service have borne out the original findings of Okonite research chemists—*that Okoloy coatings for copper conductors outlast "tinning" at least two to one.* Test after test shows that this quality feature adds years to the useful life of Okonite wires and cables.

The Okoloy process was introduced in 1928 to offset two factors frequently encountered in tin conductor-coatings which lessen long cable life—1) tin coatings readily alloy with copper in the processing bath and, as a result, some copper always remains in contact with the rubber insulation; and 2) the sulphur contained in the rubber compounds then reacts with and destroys the tin-copper coating which in turn exposes the copper conductor, eventually causing deterioration of the rubber insulation.

Okoloy affords protection against both these factors because it is a lead alloy. Of all common metals, lead is least damaged by sulphur acids. What's more, lead does not alloy with copper under the conditions encountered in coating conductors. Because processing baths are not contaminated with copper, the Okoloy coating is pure throughout. It adheres strongly to the copper conductor, and surrounds it with an acid-resistant, flexible coating which contributes materially to longer life of both rubber insulation and conductor.

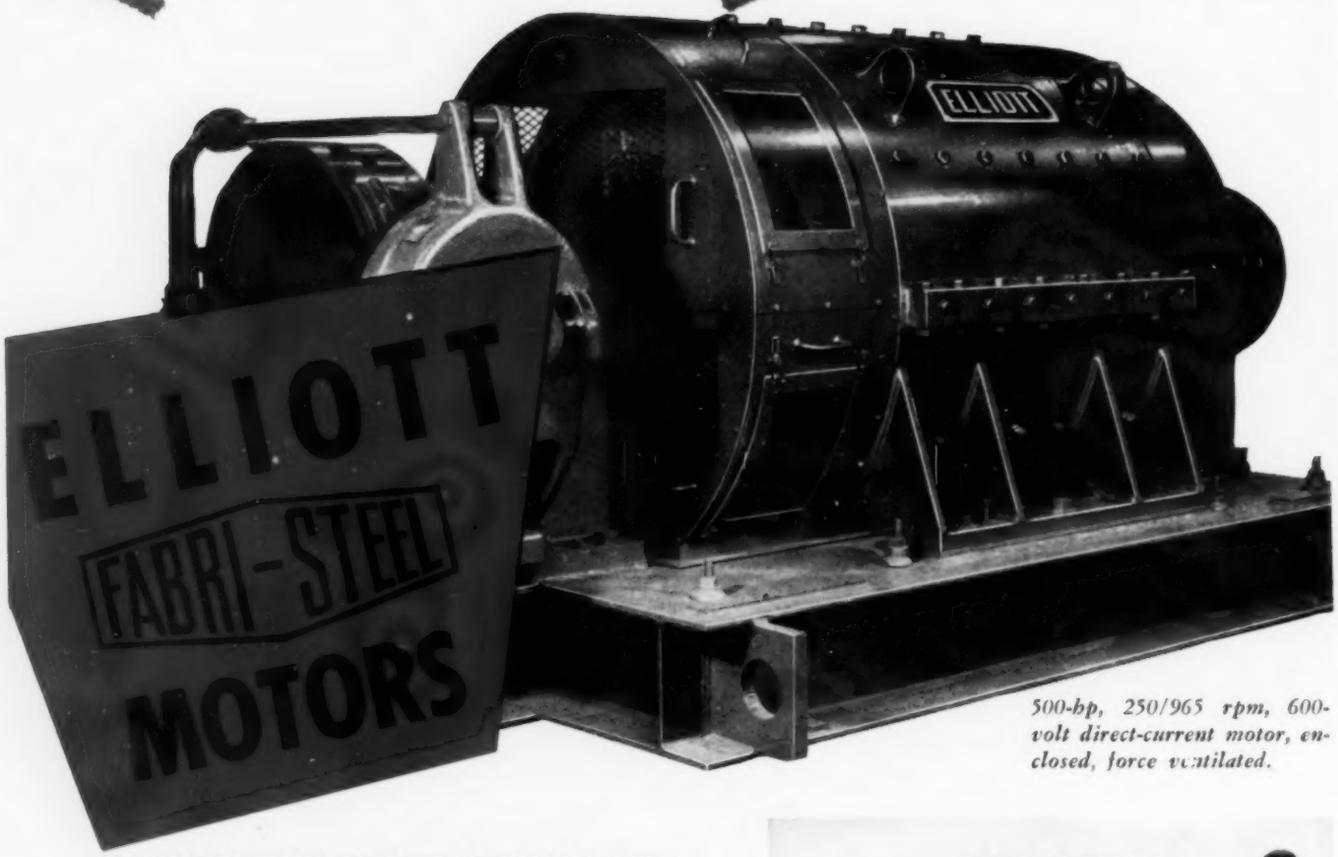
Okoloy is just one of the "longer-life" features built into Okonite products—features that give true wire and cable economy, especially in these days of high installation costs. To get complete details on how Okonite can meet your needs, we suggest that you call in an Okonite engineer, or write to The Okonite Company, Passaic, N. J.

THE BEST CABLE IS YOUR BEST POLICY

OKONITE OKONITE SINCE 1878 *insulated wires and cables*

7593

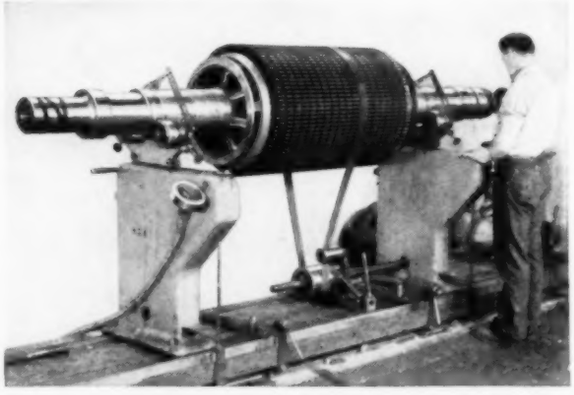
LOW inertia for HIGH production



500-hp, 250/965 rpm, 600-volt direct-current motor, enclosed, force ventilated.

FOR MODERN HIGH-SPEED ROLLING MILLS, the rapid acceleration and deceleration required are provided by Elliott "Fabri-Steel" motors expressly designed for this service in both reversing and non-reversing applications. Small diameter armatures and other design features combine with painstaking attention to details in engineering and workmanship to produce a superior machine, meeting the most exacting needs of rolling mill drives.

Write for complete data on these motors. Address Department IS.



Small diameter armature core for above motor is carefully balanced. Spider and shaft are made in one piece from a single steel forging.

OTHER FEATURES

Flawless commutation • Close speed regulation • Rugged construction with heavy overload capacity • Equal division of load on twin drives • Ready accessibility for inspection and maintenance.

MR-2

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Ridgway Division, RIDGWAY, PA.
Plants at: JEANNETTE, PA. • RIDGWAY, PA.
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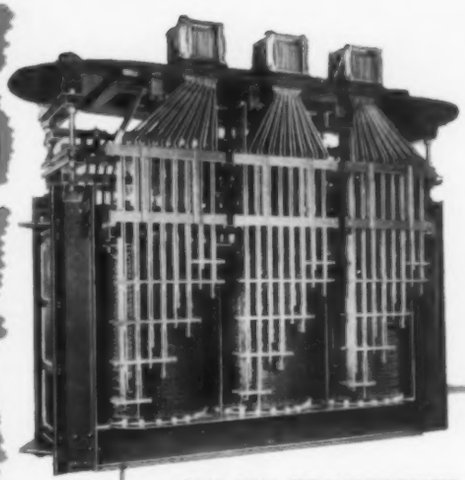
DISTRICT OFFICES IN PRINCIPAL CITIES

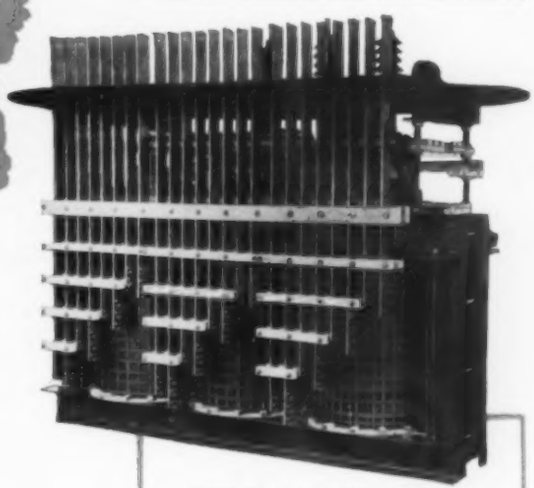
Over 1 MILLION KVA of Pennsylvania Furnace Transformers

Now in Service!

YES, Pennsylvania Furnace Transformers, totaling over 1 Million KVA, are supplying power to hundreds of electric furnaces. The successful operation of these transformers has given Pennsylvania Transformer Company a noted reputation in the Furnace Transformer field. For over 35 years, Pennsylvania Engineers have closely followed the development of Electric Furnaces. They fully understand the problems of Electric Furnaces and their relation to Furnace Transformers.

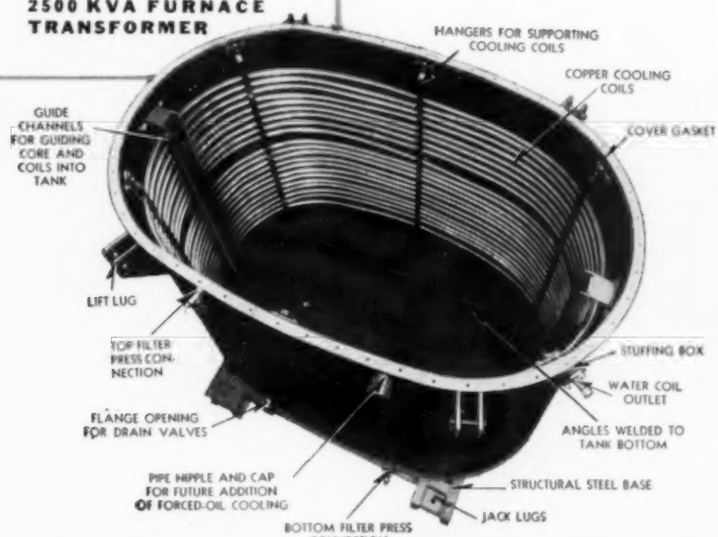


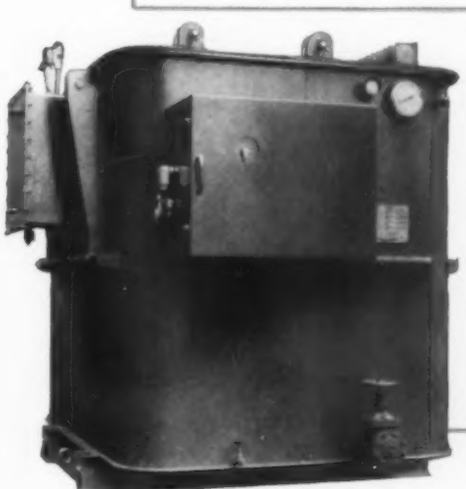
15000 KVA TRANSFORMER
for operating a 75-Ton Furnace



5000 KVA TRANSFORMER
for operating a 15-Ton Furnace

TANK INTERIOR OF 2500 KVA FURNACE TRANSFORMER


HANGERS FOR SUPPORTING COOLING COILS
COPPER COOLING COILS
GUIDE CHANNELS FOR GUIDING CORE AND COILS INTO TANK
COVER GASKET
LIFT LUG
TOP FILTER PRESS CONNECTION
STUFFING BOX
WATER COIL OUTLET
FLANGE OPENING FOR DRAIN VALVES
ANGLES WELDED TO TANK BOTTOM
PIPE NIPPLE AND CAP FOR FUTURE ADDITION OF FORCED-OIL COOLING
STRUCTURAL STEEL BASE
JACK LUGS
BOTTOM FILTER PRESS CONNECTION



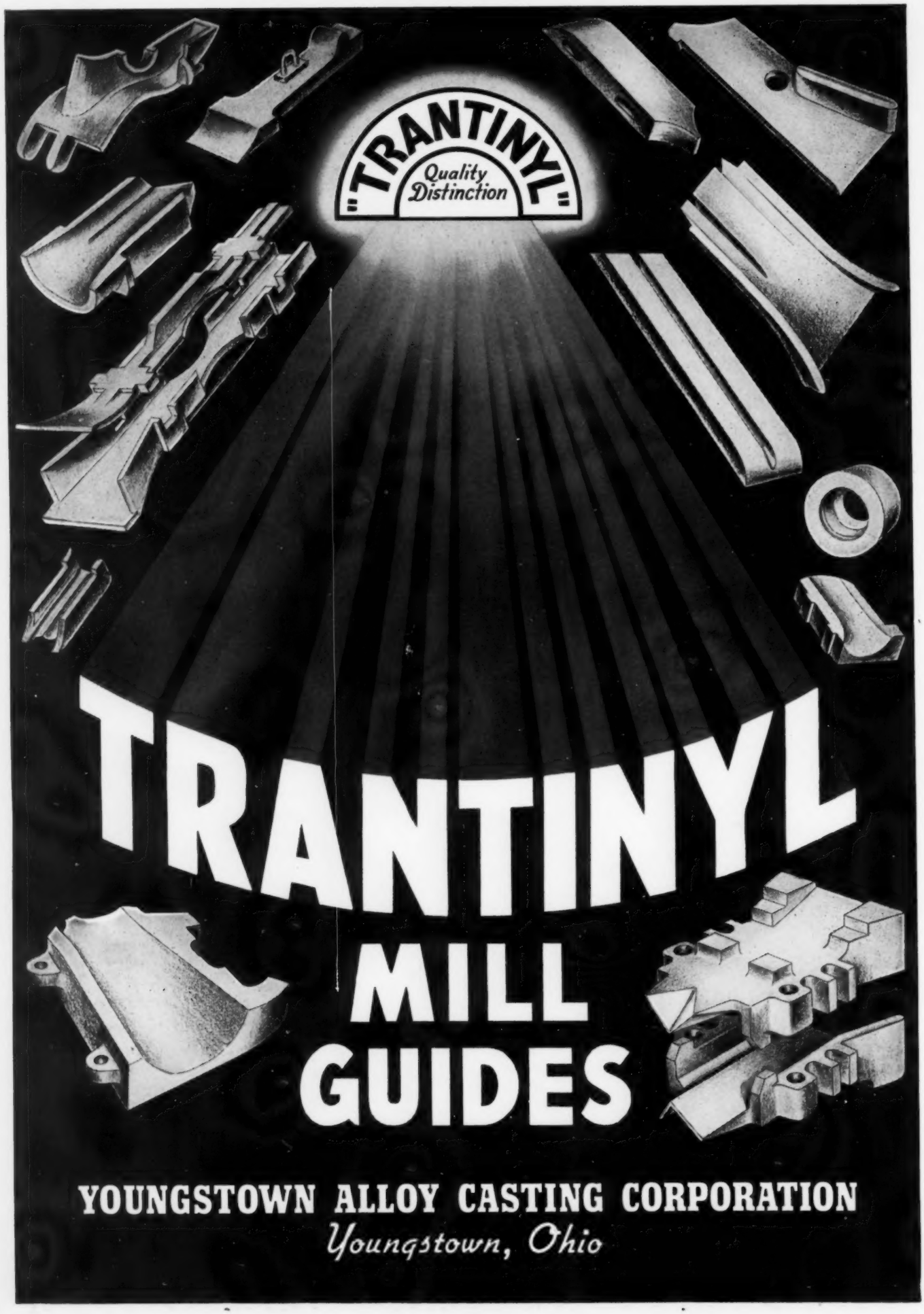
7500 KVA TRANSFORMER
for operating a 30-Ton Furnace

Pennsylvania TRANSFORMER COMPANY

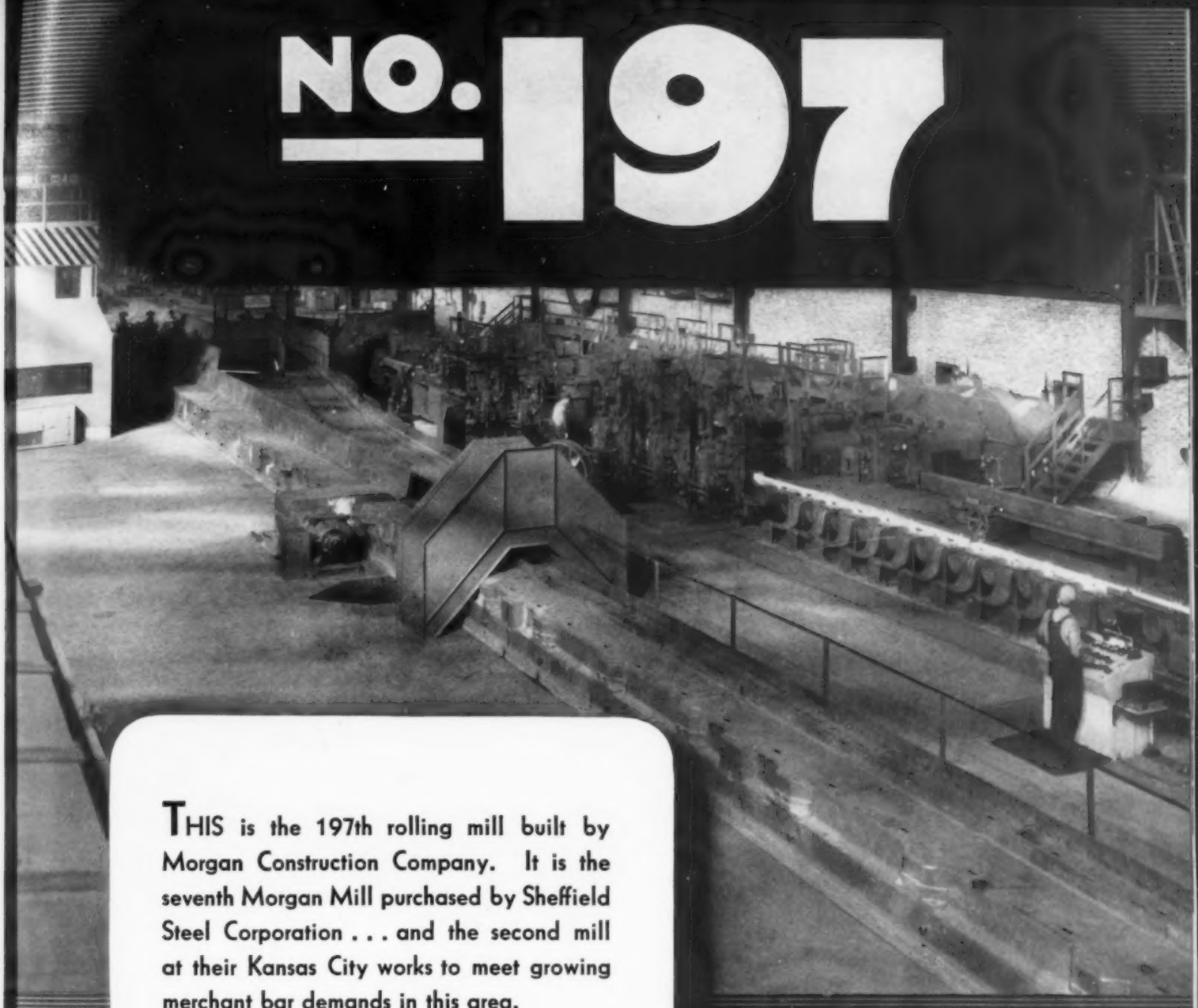
Pennsylvania TRANSFORMERS

Furnace Transformer Experts

PITTSBURGH 12, PENNSYLVANIA


"TRANTINYL"
Quality Distinction
TRANTINYL
MILL
GUIDES
YOUNGSTOWN ALLOY CASTING CORPORATION
Youngstown, Ohio

No. 197



THIS is the 197th rolling mill built by Morgan Construction Company. It is the seventh Morgan Mill purchased by Sheffield Steel Corporation . . . and the second mill at their Kansas City works to meet growing merchant bar demands in this area.

Name any outstanding producer of rolling mill products. Chances are there are one or more Morgan mills on the job . . . turning out billets, rods, strip, skelp or merchant shapes.

If you are thinking in terms of lower costs or higher output in this field, we would like to talk with you.

MORGAN CONSTRUCTION CO.

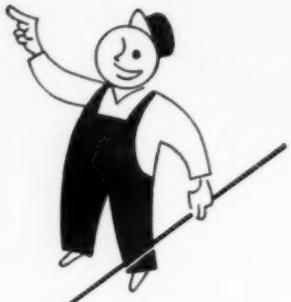
WORCESTER, MASSACHUSETTS

English Representative:
nternational Construction Co., 56 Kingsway, London, W. C. 2, England

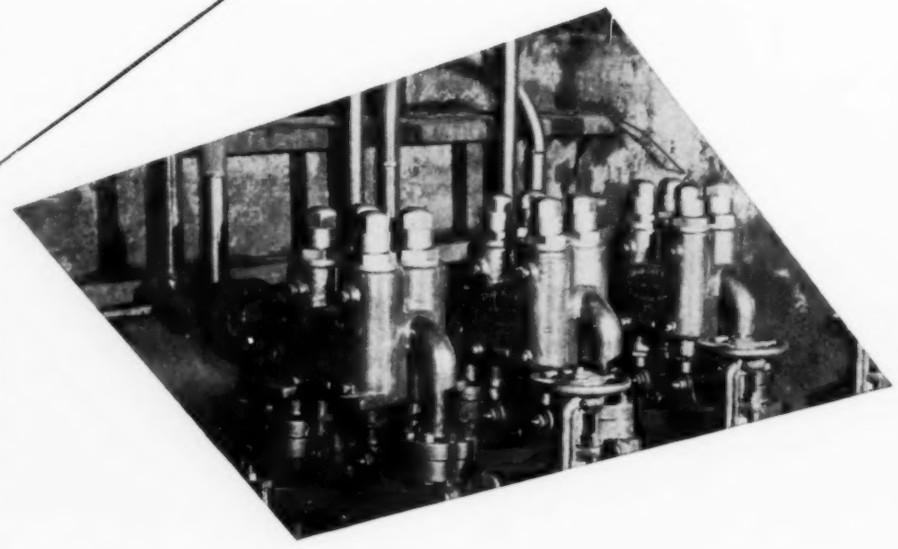
RM-22

MORGAN
WORCESTER
ROLLING MILLS - MORGOIL BEARINGS
WIRE MILLS - GAS PRODUCERS - AIR EJECTORS
REGENERATIVE FURNACE CONTROL

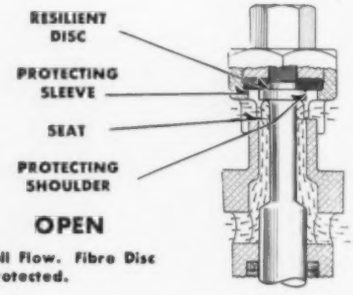
Eliminate costly shutdowns due to damaged valve seats



Modernize with HOMESTEAD *Protected Seat* HYDRAULIC Operating Valves

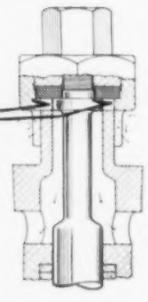


Why the Homestead Protected Seat Gives Longer, Low-Cost Service



OPEN

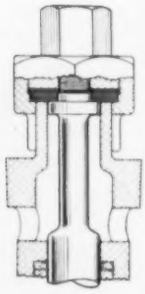
Full Flow. Fibre Disc Protected.



Large space to reduce velocity to practically zero. This ring of water is squeezed out in closing—cushions seating.

CLOSING OR OPENING

Flow practically stopped by close fitting sleeve and stem shoulder, before seat and disc make contact. This prevents wire drawing. Trapped water cushions closing.



CLOSED

Protected resilient disc against metal seat assures drop tight performance, long life, accurate control, and low maintenance.

- Shut-downs of production machinery, so frequently necessary to replace the damaged sealing elements of operating valves, are practically eliminated by the Homestead Protected Seat, an exclusive feature built into every Homestead Hydraulic Operating Valve.

"Wire drawing" or "cutting" of the seat of a Homestead Protected-Seat Operating Valve is practically impossible, because the closely fitted protecting sleeve and stem shoulder surround the metal seat and resilient disc, outside and inside, in such a way that all fluid flow is practically shut-off while the face of the seat and disc are still widely separated. In this position the fluid velocity is reduced to almost zero. Hence the common causes of leakage and subsequent shut-downs which occur with other valves, are eliminated. Grit or other foreign material in the line seldom causes leakage, because the disc absorbs it, usually without damage to the seat; and records of twelve to eighteen months of continuous service without even the replacement of a fifteen cent fibre disc, are not uncommon.

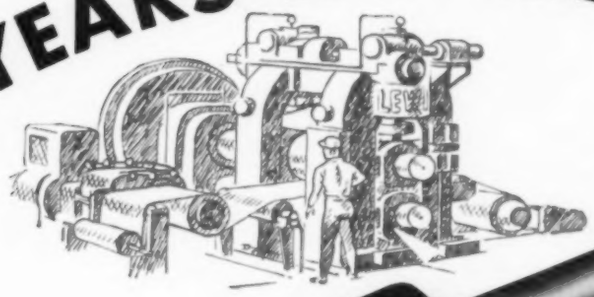
Why not find out how these dependable, trouble-free, low-maintenance valves can increase production on your present equipment by eliminating costly shut-downs? Write for Valve Reference Book No. 38. No obligation.

HOMESTEAD VALVE MANUFACTURING COMPANY

"Serving Since 1892"

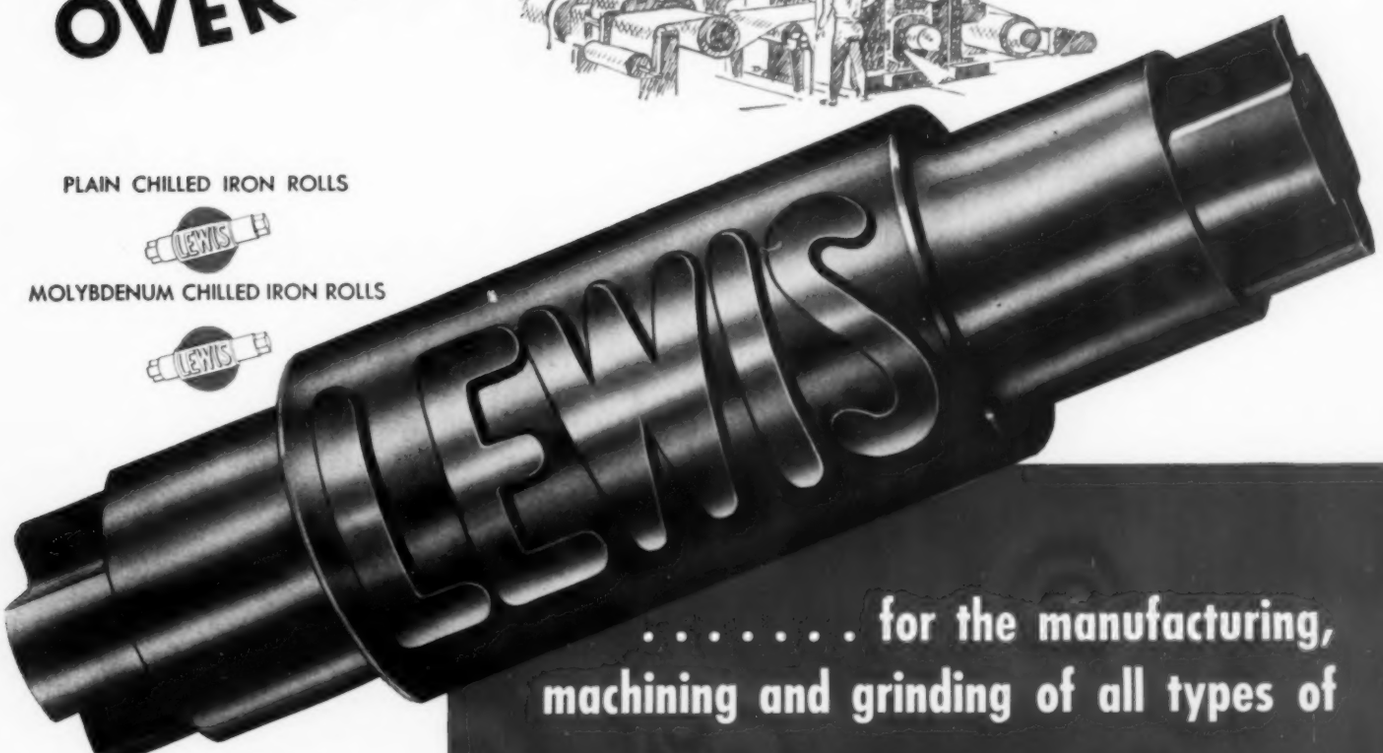
P. O. BOX 21 CORAOPOLIS, PA.

OVER 90 YEARS EXPERIENCE



PLAIN CHILLED IRON ROLLS

MOLYBDENUM CHILLED IRON ROLLS



"X" AND "XA" ROLLS
(Alloy Grain Type)

SUPERIOR "X" ROLLS
(Nickel Grain Type)

SPECIAL PROCESS ROLLS
(Chill and Grain Type)

ATLAS AND ATLAS "B" ROLLS
(Alloy Grain Type)

AJAX DUPLEX ROLLS
(High Alloy Grain Type)

CLIMAX AND AJAX ROLLS
(High Alloy Grain Type)

SPECIAL TUBE MILL ROLL

. . . . . for the manufacturing, machining and grinding of all types of

ROLLS

FOR ROLLING STEEL AND NON-FERROUS METALS

MANUFACTURERS OF
ROLLS AND ROLLING MILL MACHINERY
FOR THE IRON, STEEL AND
NON-FERROUS
INDUSTRIES

LEWIS FOUNDRY AND MACHINE DIVISION
of BLAW-KNOX COMPANY • PITTSBURGH, PA.

Speeding Production

SHEET AND TIN PLATE IN THE FAR WEST

10 FURNACES
30 BASES
in a single installation

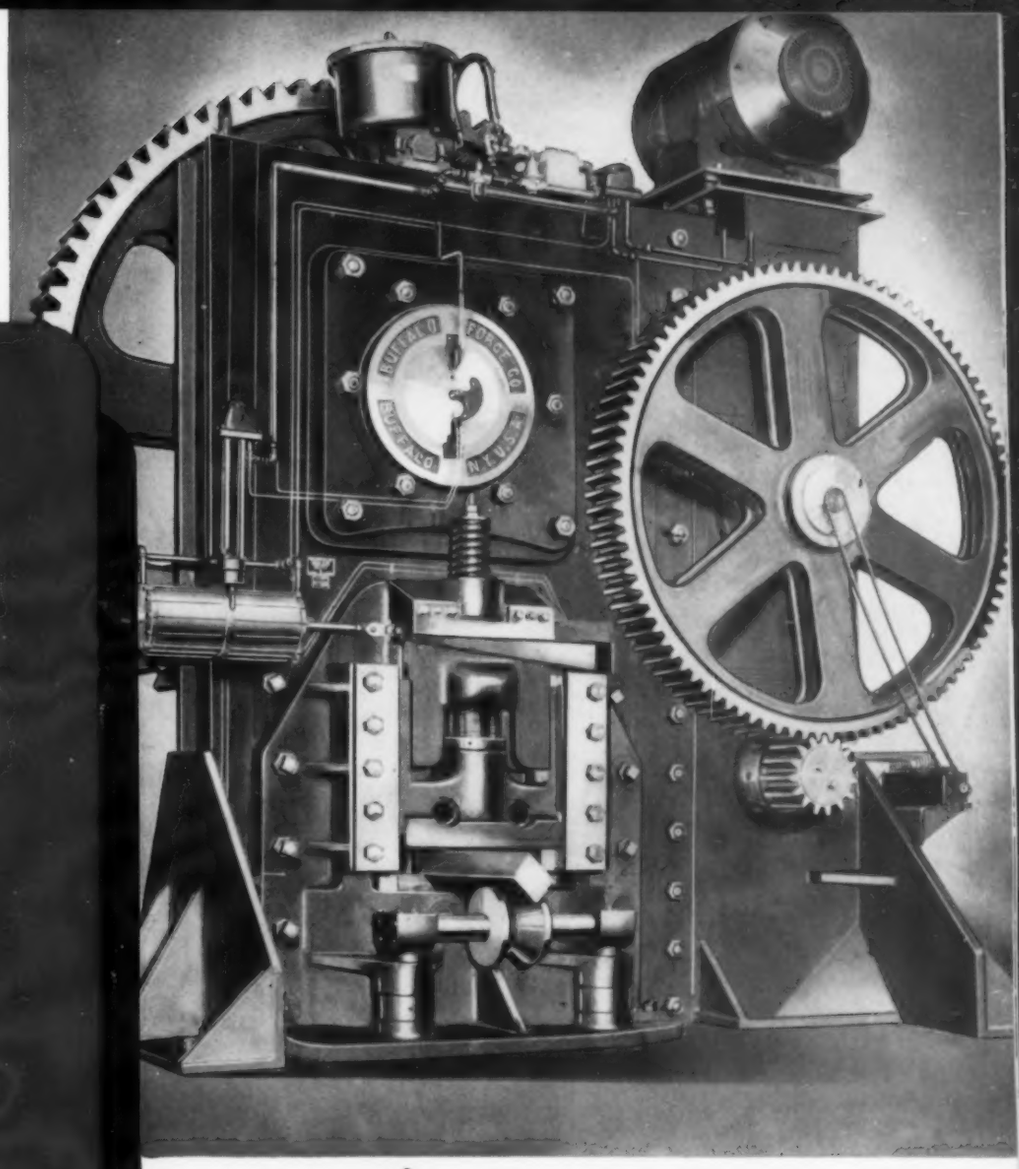
SWINDELL-DRESSLER

Recirculating

RADIANT TUBE
ANNEALING FURNACES

Ten Swindell-Dressler bell type annealing furnaces serve 30 bases in this recent installation—annealing cold-reduced steel in coils 56" O.D., piled four to a stack, eight stacks to a base. Each furnace employs 40 recirculating radiant combustion units, and measures 13'2" wide, 28'1" long, 13'9" high (interior). • *May we discuss an efficient solution to your own annealing problem?*

SWINDELL-DRESSLER Corporation
DESIGNERS AND BUILDERS OF MODERN INDUSTRIAL FURNACES
PITTSBURGH 30, PA.



6 CUTS PER MINUTE ON 10" ROUND BILLETS

"Buffalo" BILLET SHEARS

This is the tremendous shearing power and speed the No. 17 "Buffalo" Billet Shear above offers you — plus clean, accurate cuts with no "smearing." Ten other models for shearing round, flat and square stock as fast as 30 strokes a minute in the smallest size model. Electrically-welded steel plate frames, overall rigid, heavy construction to stand 'round-the-clock service for many years. SAVING MONEY IN MANY SHOPS! Bulletin 3295-A gives all details. WRITE FOR YOUR FREE COPY NOW!

BUFFALO FORGE COMPANY

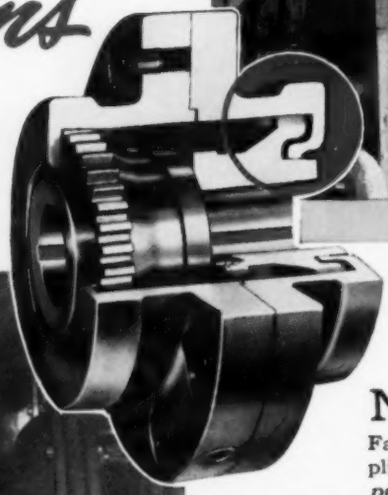
173 MORTIMER STREET BUFFALO, NEW YORK

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

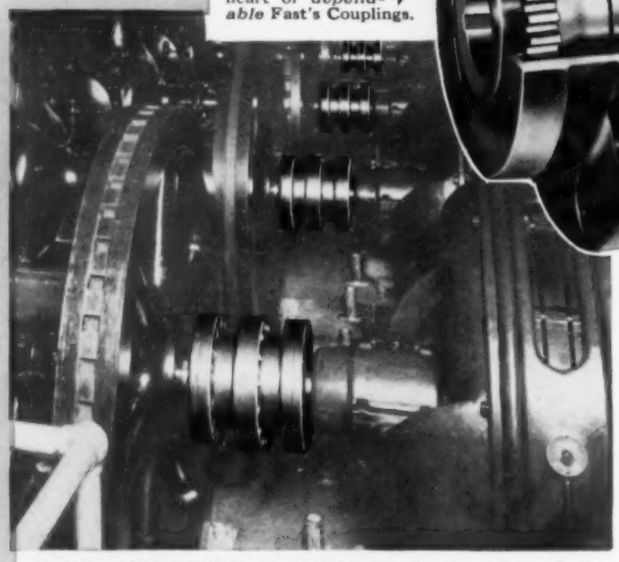
DRILLING PUNCHING SHEARING CUTTING BENDING

Here's Freedom from *Coupling Shutdowns* for ALL INDUSTRIES

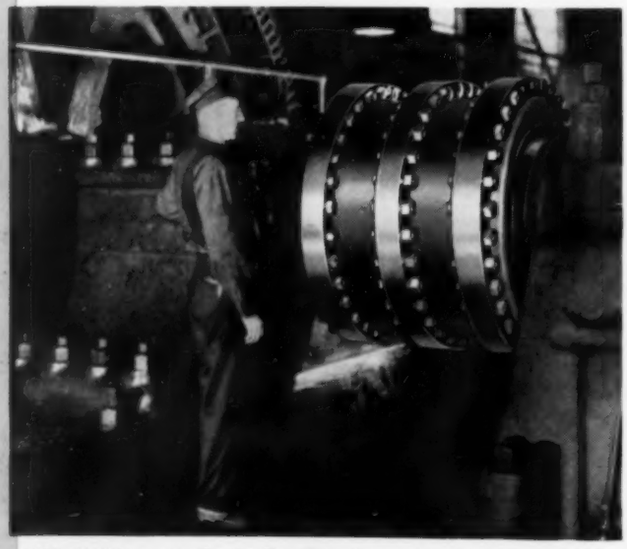
IN OIL FIELDS Fast's are in service to compensate for shaft misalignment, in all kinds of weather, subject to moisture, dirt and grit . . . yet they transmit power without costly coupling shutdowns!



Here's the *exclusive* "rocking bearing," heart of *dependable* Fast's Couplings.



CHEMICAL PROCESSING plants use Fast's Couplings because *exclusive* metal-to-metal seal keeps out impurities—eliminates lost time due to coupling failure! These Couplings have been in service since 1922!



STEEL MILLS specify Fast's Couplings for equipment of every shaft size to avoid costly production shutdowns caused by failure of ordinary couplings! This Coupling has been in use since 1923!

NO matter what you make—no matter how much horsepower you use in a year—Fast's Couplings virtually eliminate all coupling failure in your plant! There are *no perishable parts* to wear or fail in Fast's! Nothing to replace . . . they're easy to maintain. Even the load-carrying oil is *completely guarded* by a positive metal-to-metal seal formed by exclusive "rocking bearing" principle of construction.

With Fast's on your job you can forget about coupling shutdowns. Correctly engineered position of oil-protecting "rocking bearing" allows for *freedom of movement* to compensate for misalignment because its *spherical base* has *the same axis* as the hub spline faces. No perishable packing rings are used at this critical spot . . . or elsewhere!

When you order Fast's you get years of top engineering experience, Koppers' high standards of workmanship and unexcelled service, including available parts if required by change of drive, *even if your Fast's have been running for 30 years!* For full information mail the coupon below. Address Koppers Co., Inc., Fast's Coupling Dept., 217 Scott Street, Baltimore 3, Md.

KOPPERS

FAST'S *Self-Aligning* COUPLINGS

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KOPPERS CO., INC., FAST'S COUPLING DEPT.,
217 Scott Street, Baltimore 3, Md.

Please send me the free catalog that gives complete detailed information about Fast's Couplings.

NAME..... TITLE.....

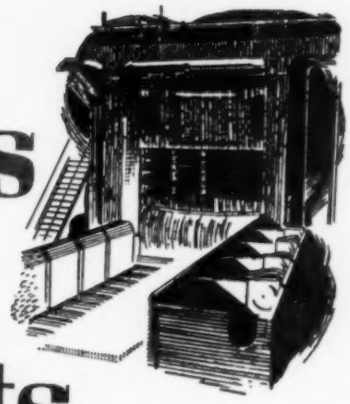
COMPANY.....

ADDRESS.....

CITY..... ZONE..... STATE.....

mail today

Crops *and* Shorts



IT is rather generally believed that steel production will drop to 70 or 75 per cent before the summer is over, but steel men are not unduly alarmed. E. T. Weir has stated: "The basic condition of business is such that there is no need for a serious recession. I do not believe there will be one if the government does not try to manipulate the economy but, instead, allows the people themselves to bring supply and demand to a normal adjustment through their own decisions on what, when, and how much to buy, and at what prices."

B. F. Fairless has said: "We in United States Steel believe that business is in a passing phase — a temporary pause in the expansion of American industry."

What is actually happening is that many industries, no doubt in expectation of lower steel prices, and knowing that steel, from now on, will be easy to get, are reducing their inventory from a six-month supply to a two-month supply. Steel, which was being produced at a rate exceeding consumption, is now being consumed faster than it is being produced.

Actually, some of us are talking a lot worse recession than we have. The present bear market is the longest on record. The dip in business, overall, during the past six months amounts to about 10 per cent. Business men in general feel that, barring upsets, the recession should not total more than 15 per cent, and that the bottom is not far off. And let's not forget that what we are now calling a recession would have been hailed as a marvelous boom during the thirties.

▲

FROM a speech by W. Walter Williams, chairman of the Committee for Economic Development, comes this recipt for a depression:

Encourage the present uncertainty about the business situation.

Increase this uncertainty with government policies lacking appreciation of the crucial role of business decisions in maintaining prosperity.

Radically cut present plans for plant and equipment expenditures.

Increase or even, in some cases, sustain profit margins.

Insist vigorously on wage increases beyond the capacity of the economy to provide them out of increased productivity.

Cut down advertising and sales promotion just when greater volume is needed.

Take fright at real and fancied economic difficulties and begin to hoard money.

THE St. Paul Association of Commerce adopted a gold pin in the shape of a shovel as its emblem of the year. The reason: "Either you dig yourself some new business during 1949, or you dig your own grave sitting around talking depression."

▲

MOVEMENT is under way to reconstruct as a permanent monument the first iron-producing furnace in the United States. Part of the foundations of the furnace, located on the right bank of the Saugus River, a few miles from Lynn, Mass., have been unearthed. Under the direction of a committee composed of members of the First Iron Works Association and the American Iron and Steel Institute, information regarding the 1643 plant is being assembled, and it is planned to reproduce the works accurately on the original site.

▲

THE Economic Cooperation Administration plans to spend $500,000 to bring officials of Marshall plan countries to the United States to learn government administration. If they want to learn how to assess and collect taxes, they couldn't come to a better place, but if they are interested in government economy, they'd better stay home.

▲

CHARLES H. KELLSTADT, of Sears, Roebuck & Co., has come up with some interesting statistics: 77.7 per cent of the people in the United States had no adult experience in World War I; 63.3 per cent had no direct knowledge about the crash of 1929; 58.4 per cent had no adult experience with a Republican administration; and (perhaps most serious) almost half of our buyers, salesmen, storekeepers, etc. have had no experience in a "free" (or buyers) market.

▲

MANY persons might have attained wisdom had they not assumed they already possessed it.

▲

ACCORDING to the American Iron and Steel Institute, there are 4000 or more separate and distinct jobs in the steel industry. The figure comes from an analysis of jobs in the industry made under the direction of the Institute's committee on industrial relations.

The combined number of common and alternate titles recorded was 13,396, and some estimates indicate that if a complete list of all titles used for all jobs could be compiled, the total would reach 50,000 to 60,000.

▲

MAN could possibly live twice as long if he didn't spend the first half of life acquiring habits that shorten the other half.

▲

THE annual conference of the National Industrial Advertisers Association, held last month in Buffalo, is said to have broken all attendance records. It was a good meeting and the committees responsible deserve a vote of congratulations.

Incidentally, some advance publicity on the meetlng advised the feminine contingent to bring suits and a coat, as Buffalo "is always assured of a cooling breeze." Someone forgot to tell the weather man — the temperature broke an 87 year record.

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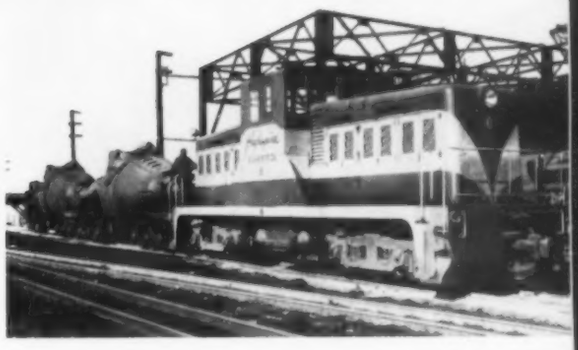
Whitcomb 70-ton Diesel electric pushing two submarine type cars of molten metal to an open hearth in the Steelton, Pennsylvania, area. Steelton & Highspire Railroad Company.



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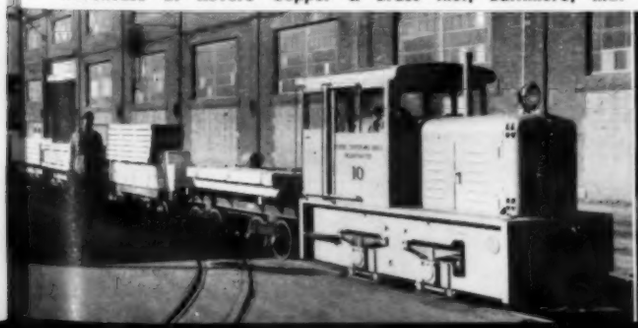
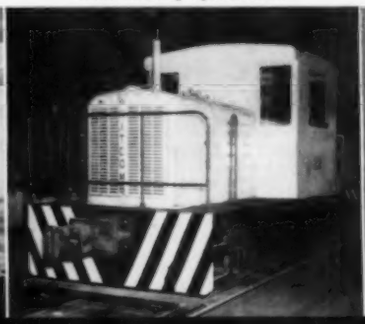


Whitcomb 20-ton Diesel mechanical locomotive of a type widely used in steel-making operations.



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Iron AND Steel ENGINEER

JULY, 1949 VOLUME XXVI NUMBER VII

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Published Monthly by
ASSOCIATION OF IRON AND STEEL ENGINEERS
1010 EMPIRE BUILDING
PITTSBURGH 22, PENNSYLVANIA

Statements and opinions given in articles and papers appearing in "Iron and Steel Engineer" are the expression of contributors, for which the Association of Iron and Steel Engineers assumes no responsibility.

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Indexed by Engineering Index and by Industrial Arts Index.

Single Copy Foreign Prepaid $2.00 Single Copy $1.50
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Blast Furnace Practice at Fontana

By C. H. LENHART*
General Superintendent
Iron and Steel Division
Kaiser Company, Inc.
Fontana, Calif.

. . . . unusually good operating results have been obtained from this blast furnace, in spite of inferior and non-uniform raw materials, because of the unusual care taken in preparing the raw materials . . . .

▲ "BESS," Kaiser Co.'s 1200-ton Fontana blast furnace, has been the proving ground for developments in blast furnace practice which have digressed far from accepted methods and have brought to light the importance of raw material segregation and classification. Built at the height of the war, "Bess" was blown in on December 31, 1942, in a location new to the steel industry.

Although "Bess" is not the first blast furnace in California, she is the first successful one. In the early days the west boasted several iron smelting furnaces, all of short duration and early vintage. The first furnace was erected at Cedar City, Utah, by the pioneer Mormons in 1852 to make iron for the new settlement in the Salt Lake Valley. Later, in 1867, an effort was made at Oswego, Ore., to establish a charcoal blast furnace for smelting the limonite ore discovered at that locality. Again, in 1881, two further attempts were made to smelt local ores, one at Clipper Cap, Calif., and one at Irondale, Wash. None of these projects has survived to the present, in spite of numerous reorganizations and furnace rebuildings.

Until the Fontana blast furnace was built and became a successful producer, many men in the steel industry claimed that basic iron could never be made economically in California due to the variable analyses and inconsistent physical make-up of western ores. Compared with uniform Eastern raw materials, those mined in the west are seemingly inferior. The coal makes weak coke, the limestone is crystalline rather than amorphous, and the chemical analysis of all these materials varies greatly from one sampling to the next, but, as has been proved at Fontana, these disadvantages can be overcome, and even, in some instances, can be developed to improve operation.

Unfamiliarity with the use of western raw materials presented a challenge to the operators in the early days of Fontana's operation. Yet, in spite of this and other problems connected with the emergencies of the war period, "Bess" produced in the five and one-half years of her first campaign, a total of 2,012,266 tons. During her peak year, 1947, she averaged 1259 tons, with a coke rate of 1416 pounds per ton. Her record day was on April 27, 1947 when she made 1534 tons, and for that month she set a record of 41,529 tons, with a coke rate of 1360 pounds per ton.

During 1943 and 1944, total tonnages were 299,737 and 354,098 respectively, with a slacking off during parts of 1945 and 1946 when she was fanned for a year in a curtailment program following the end of the war. In July, 1946, full blast was restored and she was averaging 1199 tons per day with a coke rate of 1463 pounds per ton until torn down for relining after a hearth breakout on July 23rd.

Throughout the five and one-half years of operation, the problem of using non-uniform raw materials has caused the operators to work along the lines of ore beneficiation and improvement of coke quality, until proc-

Presented before AISE Annual Convention, Cleveland, Ohio, September 28, 1948

* Mr. Lenhart is now vice president, H. A. Brassert and Co.

esses have been developed to handle the raw materials with very encouraging results.

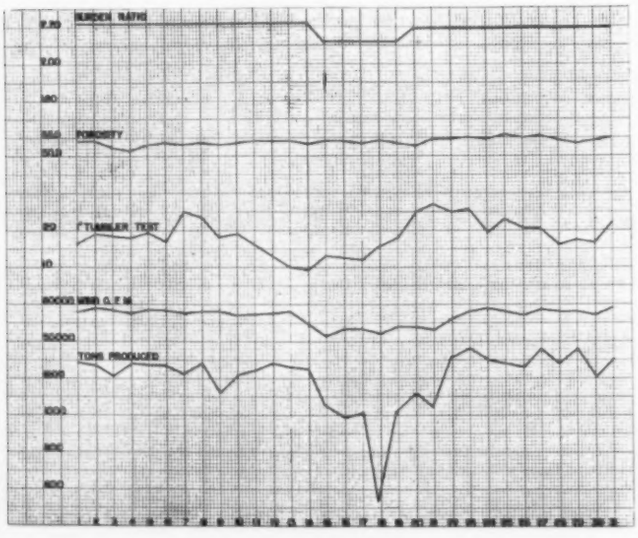
HISTORY

Having a hearth diameter of 25 ft 6 in. and 16 tuyeres, "Bess" has gone through an extensive trial and error period since being blown in on December 31, 1942, to determine the proper amount of wind to blow, the proper ore sizing, the proper filling, the proper coal mixture for the coke, and adjustment of all the other variables which control furnace operation. Solving these problems was particularly difficult because no one previously had attempted to adapt these western raw materials to blast furnace operation, and there was no background of information available to guide the operators.

Raw materials first used were Vulcan ore, dug from a small pit mine in the California Mojave Desert, and coke made from 100 per cent Sunnyside coal, mined in Utah. The Vulcan ore contained approximately 51 per cent iron and 0.060 per cent sulphur during the initial operating period and was satisfactory for use. After further mining, however, the sulphur content showed continuous increases until in December 1944 it averaged 1.2 per cent, with a high of 1.85 per cent. Even by sintering 60 per cent of the ore (limited by the sintering plant capacity), it was not possible to produce an economical ore mix. To eliminate the sulphur, a slag volume averaging 2100 pounds per ton, with a high of 2620 pounds per ton, was required during November 1944.

In spite of the poor ore and weak coke produced from 100 per cent Sunnyside coal, in September 1943, after seven months of operation, the furnace produced an average of 1154 tons per day, with a coke rate of 1788 pounds per ton. Low volatile coal was added to the coal mixture in May 1944, and, in December 1944, Utah ore which was low in sulphur but high in phosphorus (average 0.250 per cent), was introduced into the furnace

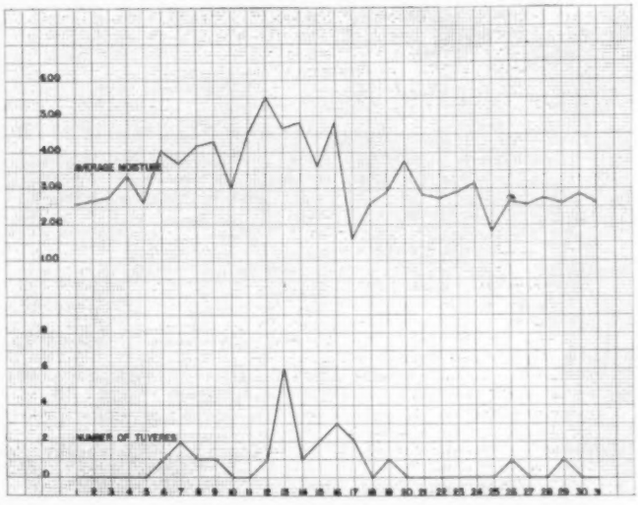
Figure 1 — Data for January 1947 shows how furnace operation was affected by coke strength.



burden. By proper proportioning of Utah ore, Vulcan ore and sinter, a satisfactory burden was obtained, which in May 1945 produced 38,921 tons (1245 tons per day) on a coke rate of 1468 pounds per ton. The reconversion period following the war then set in and no further improvements in production could be made due to slack wind blowing.

In July 1946, full wind was again restored to the furnace and from that time, continued improvements in furnace practice were made. By January 1947, changes in the crushing system were completed, permitting all of the high sulphur ore to be converted into sinter before being placed on the furnace burden. After experimenting with the amounts of Utah ore and Vulcan sinter, a 50-50 burden was decided as the proper proportion for this furnace. This brought about the record month of May 1947, with a tonnage of 41,529, which represents a daily average of 1340 tons (2.62 tons per square foot of hearth area) with a coke rate of 1363 pounds per ton, a flue dust production of 44 pounds per ton, and a slag volume of 803 pounds per ton. As the high sulphur Vulcan ore was gradually withdrawn from

Figure 2 — Tuyere loss increases with coke moisture as shown in this chart for May 1947.



the burden, the slag volume also dropped and was kept at around 800 pounds per ton during the last year of the campaign. The lowest coke rate was obtained in July 1947 when the furnace averaged 1318 tons per day with a coke rate of 1360 pounds per ton. After December 1946, the monthly coke rate was under 1400 pounds per ton for three individual months, and was over 1500 pounds per ton during only one month.

COKE

In operations at Fontana, as at most other plants, the coke rate is extremely important in determining the cost of hot metal, inasmuch as it is by far the most expensive raw material put into the furnace in any appreciable tonnage. It is therefore necessary for the furnace operator to make every effort to get the coke which is best suited to his operation in order to obtain the lowest possible coke rate.

The coke presently used at Fontana is produced from a coal mixture of approximately 88 to 89 per cent high-volatile Sunnyside coal from Utah, 10 per cent low-volatile coal from Oklahoma, and a small percentage (1 to 2 per cent) of pitch. The Sunnyside coal is crushed to minus 8 inches at the mine and is then screened over a 3-inch screen. The minus 3-inch portion is subjected to a washing process which removes approximately 2 per cent ash and 0.2 per cent sulphur. The plus 3-inch material is hand picked free of rock and slate and then mixed with the washed coal for shipment to Fontana.

None of the low-volatile coal is subjected to any grading or washing other than hand picking and screening. Only the minus 2½-inch low volatile coal is currently being purchased. The average proximate analysis of the two coals is as follows:

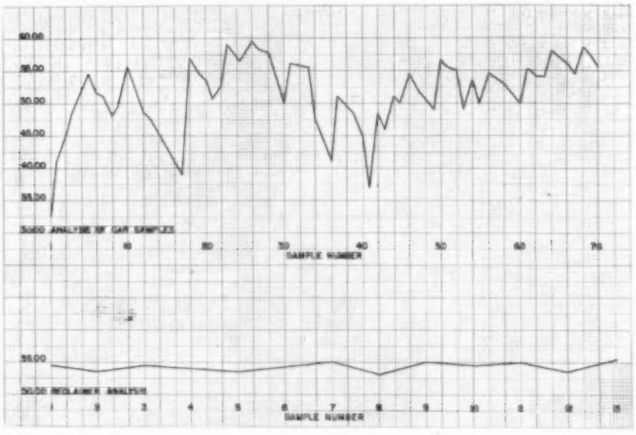


Figure 3 — Effect of bedding on iron analysis.

TABLE I — COAL ANALYSES

	High-volatile, per cent	Low-volatile, per cent	Mixture, per cent
Moisture	6.8	4.3	5.7
Volatile matter	38.9	18.0	37.0
Ash	7.7	10.3	8.1
Fixed carbon	53.4	71.7	54.9
Sulphur	1.23	0.85	1.18

Experience has shown that the properties of the coal vary enough from day to day to make it impossible to produce good blast furnace coke without some blending. At the present time all coal is stocked prior to use, permitting mixing of the total output of the mine for 30 to 60 days.

After leaving the stockpile on the way to the ovens, the coal passes through a breaker, the mixing bins, and a hammermill. As the coal is carried from the breaker to the mixer building, the flaked coal-tar pitch is placed on top of the coal stream. The pitch flows from a storage bin adjacent to the breaker building onto a continuous belt which is mounted on a scale. This automatically keeps a fixed amount of pitch (25 to 27 tons per day) flowing onto the coal as it is carried to the mix bins.

The mixer building contains four storage bins, each

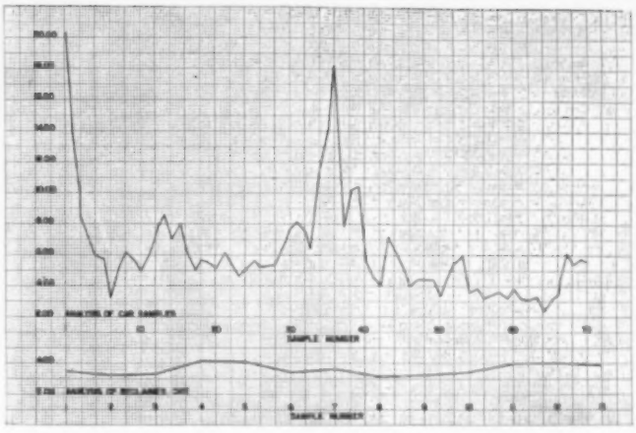


Figure 4 — Effect of bedding on silicon analysis.

having a capacity of 150 tons. Two bins are filled with Sunnyside coal and two with low-volatile coal. From the mixing bins the two coals are proportioned so that the mixture is carried by continuous belt from the bins to the hammermill. In the hammermill, the size of the coal is further reduced so that 65 to 70 per cent will pass through a ⅛-in. screen. The hammermill serves a dual purpose in that it thoroughly blends the low-volatile and Sunnyside coals, as well as reducing their size.

The capacity of the coal handling system is 250 to 275 tons per hour, or 1300 to 1500 tons per day, operating at the present rate of one turn per day.

The coke ovens consist of two batteries, each having 45 under-jet combination ovens. The average width of the oven is 14¼ in. with a 2½ in. taper. The oven height is 13 ft, with a 12-ft coal line and a length of 40 ft, 5½ in. Approximately 8.7 tons of furnace coke are produced by each oven from a coal charge of approximately 14.4 tons. The normal coking time averages from 20 to 21 hours, with an oven wall temperature of 2050 to 2100 F.

The proper quenching of the hot coke is very closely watched, inasmuch as the operators strive to hold the moisture content of the blast furnace coke under 3 per cent. The quenched coke travels by conveyor belt to the blast furnace storage bins, with every effort being made to handle the coke as gently as possible. For example, the conveyor tripper over the bin is continually being moved so the coke will always fall on coke and have the least possible distance to drop. Just before it falls into the blast furnace charging skip, the coke is screened over a ⅞-in. screen. Screening prior to that point is felt to be more detrimental than beneficial to the coke due to excessive breakage as the coke goes over the screen.

The coke produced at Fontana is relatively weak but porous. The ASTM 1-in. tumbler tests vary from 18 to 25 per cent, and the porosity from 52 to 55 per cent. Chemically, this coke is satisfactory, having an average ash of 11.2 per cent and an average sulphur content of 0.98 per cent during 1947. It was discovered quite some time ago, after numerous experiments with cokes of various strengths, that, with the type of burden used, a coke strong enough to give 18 to 25 per cent on the 1-in. tumbler test was satisfactory for good operation. When the coke strength is maintained in this range, the porosity usually is high (52 to 55) resulting in a coke

which will burn rapidly in front of the tuyeres. No effort is made to produce excessive strength in the coke, but only sufficient strength to afford good operation and still not sacrifice porosity, which usually varies indirectly with the strength.

Figure 1, showing operational data for January 1947, indicates the relationship coke strength (1 in. tumbler) and furnace operation. Between January 11th and 19th, when the coke tumbler dropped well below the critical 18 per cent, the burden and wind had to be reduced to keep the furnace hot and also to keep it moving. The result was lost tonnage.

The first sign of trouble was "hanging," which indicated that the coke was disintegrating in the stack. To offset this, the furnace was "checked" every thirty minutes; as the furnace became progressively "colder," the burden was reduced. Six to twelve hours after the "hanging" began, tuyeres started to burn, and when the furnace was taken off, very fine coke was found in the vicinity of the tuyeres. Messes of fine coke accompanied nearly every cast, although the tapping hole was long and dry. As the quality of the coke improved, the furnace immediately responded and returned to normal operation, as is indicated in Figure 1.

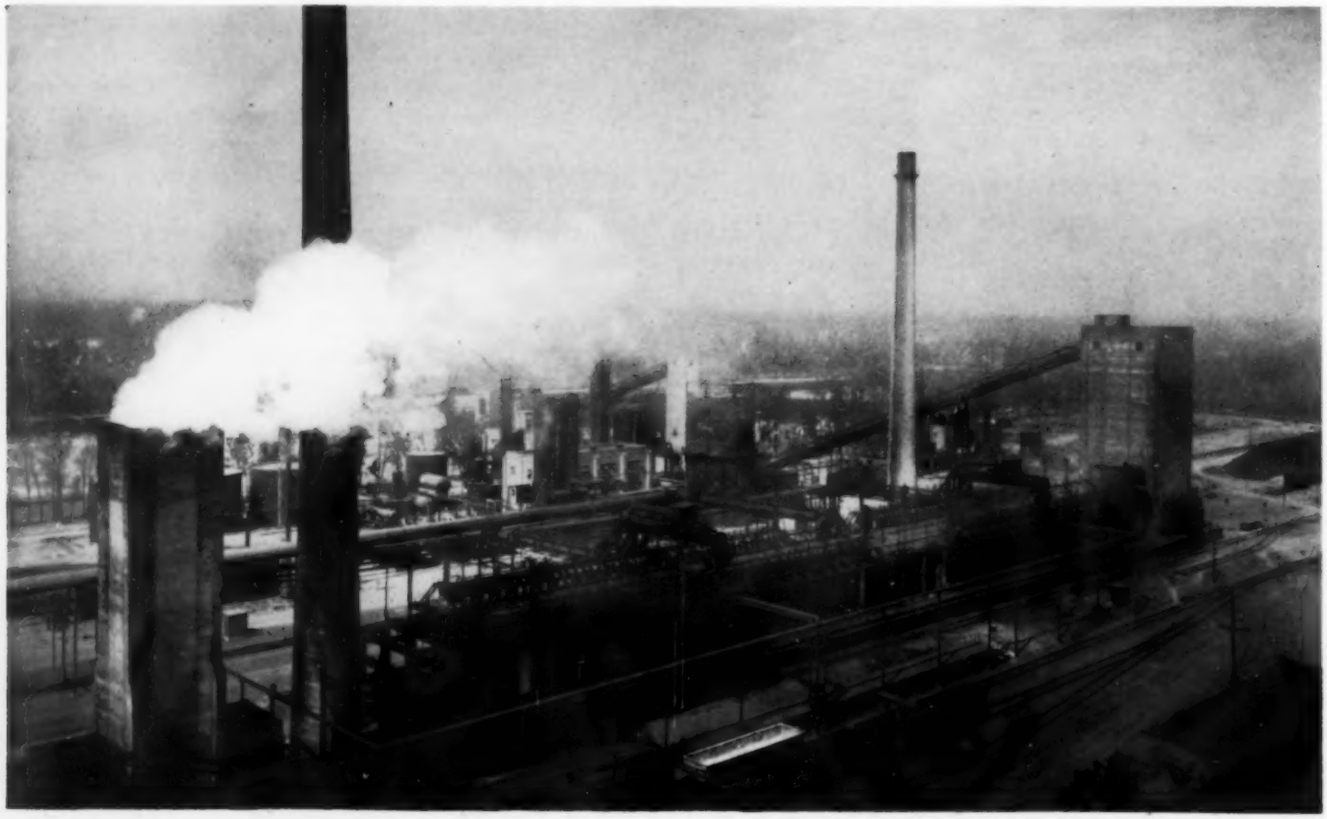
The relatively weak coke used at Fontana has been found to be very sensitive to variations in moisture content. There is a definite relationship between the moisture content of the coke and the way it stands up while traveling through the furnace. Coke containing moisture much higher than 3 per cent with normal quenching will generally cause furnace trouble similar to that brought about by coke having a low 1-in. tumbler index. Irregularities, such as periods of hanging, loss of tuyeres, and coke messes, can usually be expected if coke with high moisture content (3.5 per cent or over) is consistently charged into the furnace. Even with very close supervision over the quenching operation, it is often difficult to control the moisture content of the coke. At times when the coke is good, holding the moisture below 3 per cent is not difficult. However, at times when the coke is inferior, the same quenching practice will result in high moistures.

Figure II indicates in general the relationship between coke moistures and tuyere losses, showing evidence that tuyere losses are directly influenced by moisture content in the coke. Two noticeable periods of high coke moisture content occurred during May 1947. The first period, between May 5th and 9th, resulted in the loss of five tuyeres; the second period, between May 11th and 17th, resulted in the loss of fifteen tuyeres. During the other nineteen days of the month, when the coke moisture remained closer to 3 per cent, only three tuyeres were burned.

BENEFICIATION OF ORES

Since December 1944, the primary iron-bearing ores used at Fontana have been Utah ore and Vulcan ore, both of which have been satisfactory in Fe content but not entirely satisfactory in other aspects. Table II gives a six-months' average analysis of the raw materials used at Fontana.

Figure 5 — Coke is made in two batteries, each having 45 under-jet combination ovens.



In an effort to eliminate the undesirable qualities of these ores, certain basic beneficiation processes must be employed. These processes include crushing, screening, bedding and sintering. Each of these processes is necessary to successful furnace operation, and it would be practically impossible to produce uniform basic iron, or iron of any desired quality at Fontana, if beneficiation equipment were not available.

TABLE II — ANALYSIS OF RAW MATERIALS

(6 Months' Average)

	Utah	Vulcan fines	Sinter	Lime-stone	Coke
SiO_2	7.04	4.74	6.08	3.56	5.48
Al_2O_3	2.05	0.64	1.36	1.72	2.87
CaO	1.64	2.81	3.23	48.04	0.51
MgO	2.04	4.66	5.00	3.43	0.12
Fe	55.17	54.04	57.72	1.31	0.62
Phos	0.234	0.045	0.079	0.031	0.045
Mn	0.06	0.05	0.11	...	...
S	0.037	1.85	0.045	0.065	0.94
F.C.	...	...	...	...	86.4
Moisture	3.1	0.30	0.20	0.20	2.8

The most undesirable feature of all western ore is the variation in chemical composition from day to day, and even from carload to carload. In order to eliminate this variation before the ore goes to the furnace bins, a bedding and reclaiming system is employed. A stacker, traveling back and forth along the entire length of the stockpile, beds the ore onto a pile, thus blending the ore from approximately 200 cars (13,000 to 14,000 tons) into one stockpile. When the ore is sent to the furnace, a reclaimer moves into the face of the pile and completes the blending operation by raking the ore from a cross section of the pile, perpendicular to the direction of the bedding. Figures 3 and 4 show the necessity for and the benefits derived from this bedding and reclaiming system. These charts present the analysis of seventy samples of Vulcan ore going to a stockpile, as compared with that of thirteen daily samples as reclaimed from the same stockpile. The leveling of variations in chemical composition is very noticeable. The average analysis of ingoing ore and reclaimed ore shown on the charts is not comparable, since the charts do not indicate the quantity of ore blended, but only the chemical composition. The great importance of such a bedding system to furnace operation is only fully appreciated at times when, due to mechanical breakdown or other emergencies, it cannot be used. During these rare occasions, control of the analysis of the iron produced is practically impossible, regardless of how skilled the furnace operator may be.

We are firmly of the opinion that good furnace operation depends to a great extent not only upon chemically-uniform, high-grade raw materials, but also upon proper sizing of such materials. It is therefore highly desirable that the blast furnace operator be furnished with equipment to control the size as well as the analysis of the ores. At Fontana, a very flexible system is provided, consisting of a 48-in. by 38-in. superior jaw crusher, two 5½-in. standard cone crushers, two shorthead crushers, and single and double-deck vibrating screens, which permit crushing and screening of ores to any desired size.

Figure 6 — Overall view of raw materials area.

At the present time, the Utah ore is crushed to a size range from 0 to 2½ in. Figure 6 outlines the flow of ore through the crushing and screening system. After crushing and screening, all ore is bedded on the stockpiles with no further grading. Furnace operation has been so successful with Utah ore graded to particle size from 0 to 2½ in. that no further sizing is considered necessary. A typical screen test of Utah ore follows:

TABLE III — UTAH ORE SCREEN TEST

Screen, in.	Per cent	Accumulative per cent
+3	0.0	0.0
+2	1.5	1.5
+1½	9.2	10.7
+1	13.2	23.9
+½	26.9	50.8
+¼	14.7	65.5
+⅛	9.6	75.1
−⅛	24.9	100.0

This ore is well balanced with respect to particle size, having approximately 50 per cent plus ½-in. and 50 per cent minus ½-in. It is believed that this balance is an important factor in obtaining proper radial distribution of ore at the furnace stockline. When charged into the furnace, enough coarse material is present to allow a portion of it to roll to the center, while the fines remain along the walls.

Although part of the 24.0 per cent of minus ⅛-in. material is recognized as potential flue dust, it has not been found economical to separate and sinter it, in view of the present low flue-dust rate of the furnace. In the past, some Utah fines have been used in the ore mix at the sinter plant, but no improvement was apparent in the physical properties of the sinter, and definite disadvantages were introduced into the chemical analysis in the form of phosphorus.

Vulcan ore, mined at Kelso, Calif., presents a slightly different beneficiation problem than Utah ore. In addition to its variations in chemical analysis, it is extremely high in sulphur, often in excess of 2 per cent, which makes it uneconomical for use in the furnace

without first being sintered to reduce the sulphur content. Inasmuch as the ore is received at Fontana in particle size from 0 to 10-in., crushing is necessary so the particle size will permit maximum desulphurization during sintering. Crushing, to enable 100 per cent of the ore to pass through a ⅝-in. screen has been found satisfactory for removal of 95 per cent of the sulphur.

After crushing, the ore is bedded in order to eliminate variations in chemical analysis before it is sent to the sintering plant storage bins. The chemical analysis of the sinter feed is further leveled off at the sinter plant by feeding ore into the sinter machine from as many storage bins as possible. In fact, at times when it has been impossible to bed the ore, a very uniform sinter has been produced merely by drawing ore, sent directly to the sintering plant bins from the crushers, out of at least three of the bins. To get desirable uniformity, however, both bedding and drawing from more than one bin are employed whenever possible.

In the sintering operation at Fontana, emphasis is placed on sinter quality rather than on tonnage. The machine is rated at 1500 tons per day, but this tonnage figure is not the ultimate goal of the sintering operation. Regardless of what tonnage is produced, the sinter must be of suitable quality both physically and chemically to allow economical furnace operation. Normally 1300 tons of quality sinter can be produced each day, or an average of 50 net tons per hour, including delays.

The only positive proof of the quality of sinter (or of any raw material, as a matter of fact) is blast furnace operation. Other things being constant, if the sinter is good, operation is good; and if the sinter is bad, operation is bad. This practical test, however, is only conclusive for specific operating conditions, and it is not necessarily true that what proves to be good sinter at one plant would be satisfactory at another plant using different raw materials and practice. Good blast furnace operation results only when the combination of a number of factors is favorable.

The average chemical composition of the sinter at Fontana is as follows:

TABLE IV — AVERAGE SINTER ANALYSIS

	Per cent
SiO_2	6.08
Al_2O_3	1.36
CaO	3.23
MgO	5.00
Fe	57.72
Phos	0.079
Mn	0.11
Sulphur	0.045

The Fe content is high, while the sulphur and phosphorus percentages are suitable for producing basic iron. This sinter is self-fluxing, having about 1 per cent more bases (CaO and MgO) than actually necessary to flux the SiO_2 and Al_2O_3. The excess in available bases is advantageous not only in permitting the use of less limestone in the furnace burden, but also in retarding any formation of iron silicates during the sinter process.

The sinter produced from Vulcan ore is very porous, a characteristic which encourages good gas-solid contact in the furnace stack. It is relatively soft, and all possible is done to maintain this consistency, as experience has shown that hard sinter is difficult to reduce. Excessively high sintering temperatures are avoided as they tend to produce a hard, bulky sinter.

Due to relatively gentle handling of the sinter on conveyor belts from the sinter machine to the stockpile and then to the furnace bins, soft sinter can be transported without deteriorating into any appreciable amount of fines. As an example, the following typical screen test made at the furnace bins shows only 7.4 per cent smaller than ⅛-in., part of which could be considered potential flue dust:

TABLE V — TYPICAL SCREEN TEST OF SINTER AT BINS

	Per cent	Cumulative per cent
On 4 in.	0.9	0.9
On 3 in.	0.0	0.9
On 2 in.	0.5	1.4
On 1½ in.	0.8	2.2
On 1 in.	4.8	7.0
On ½ in.	37.1	44.1
On ¼ in.	39.2	83.3
On ⅛ in.	9.3	92.6
Through ⅛ in.	7.4	100.0

When handling sinter by conveyor belts, it is imperative that it be cooled to a temperature which will not damage the belts. Cooling can be done in either of two ways, quenching with large volumes of water to bring down the temperature rapidly, or cooling by air to bring down the temperature slowly. Quenching proved to be unsatisfactory at Fontana, because the intense thermal shock accompanying water cooling caused the sinter to shatter, producing an increased percentage of fine material. An added disadvantage was a hard, glazed surface on the sinter particles, which appeared to retard reduction of the sinter in the furnace.

As a means of eliminating water cooling, a large round cooling table was installed at the discharge end of the machine. The sinter is discharged onto the top of the cooling table where it remains approximately two hours, during which time the temperature is brought

Figure 7 — Stackers are used for bedding the raw materials in order to attain uniformity.

Figure 8 — After crushing and screening, ore is bedded on the stock piles without further grading.

down from an average of 614 F to 230 F. The table has a slow rotary movement which causes the hot sinter to be fed evenly onto the surface and the cool sinter to be reclaimed from the bottom by means of a stationary plow. The capacity of the table is approximately 200 tons, and the speed at which is turns permits the sinter to be fed onto the conveyor belt at a rate of 50 to 60 tons per hour. This method of air cooling has proved very satisfactory and has completely eliminated the necessity of using water. As a comparison of the two methods, screen tests made of water-cooled sinter show approximately 23 per cent in particles of minus ⅛-in., while with air-cooled only 8 per cent.

LIMESTONE

As indicated in Table II (Analysis of Raw Materials), the amount of SiO_2 and Al_2O_3 in the Utah ore and Vulcan sinter is relatively low and the CaO and MgO is relatively high, as compared to the analysis of the ores used in some other parts of the country. This phenomena, along with a very reasonable coke ash of 11 per cent, results in much less slag per ton of iron than is usually produced, and a corresponding decrease in the amount of limestone required per ton of iron. During normal operation the slag volume at Fontana is approximately 800 pounds per ton and the limestone used in the burden amounts to 150 to 200 pounds per ton. It is evident that limestone is not nearly as critical a raw material at Fontana as it is in plants which require 600 to 800 pounds per ton to flux the gangue in the ores and ash in the coke.

The stone which is used is quarried in Colton, Calif., about 15 miles from the blast furnace. It has in general a dense, crystalline structure, with only a very small per cent of it in the amorphous state. Although the percentage of acid and basic constituents vary from day to day, the average available base is generally between 43 and 46 per cent. Excellent results have been obtained with this stone when it is sized to contain particles from 1⅛-in. to 4-in.

BURDENING OF FURNACE

The raw materials described above are used to produce basic iron, all of which is currently consumed in the open hearths. The normal furnace burden is as follows:

TABLE VI — NORMAL FURNACE BURDEN

Material	Per cent	Pounds
Utah ore	49.7	18,800
Sinter	49.7	18,800
Mn ore	0.6	200
TOTAL ORE	100.0	37,800
Coke	.....	17,000
Limestone	6.3	2,400
Open hearth slag	6.6	2,500
Roll scale	5.3	2,000
TOTAL CHARGE		60,900
Slag per ton of iron		800 lb
Ratio ($CaO + MgO \div SiO_2 + Al_2O_3$)		0.99
Theoretical coke		1365 lb/ton
Burden ratio (Ore mix ÷ Coke)		2.22
Limestone per ton of iron		193 lb

TABLE VII — METHOD OF FILLING FURNACE

First skip	Sinter
Second skip	Stone Slag Scale
Third skip	Coke
Fourth skip	Coke
Dump Big Bell	
Fifth skip	Utah ore
Sixth skip	Coke
Seventh skip	Coke

The above burden and filling have been used on the furnace for the past two years with practically no change. Results have been excellent and it is believed this constancy in charging the furnace has had a direct bearing on the results.

The iron produced normally meets the requirements of the basic open hearth, which is as follows:

TABLE VIII

Basic open hearth iron analysis		Average slag analysis	
Si	0.75 — 1.25	SiO_2	35.90
Mn	0.50 — 1.00	Al_2O_3	12.95
Sul	0.050 maximum	CaO	31.65
Phos	0.400 maximum	MgO	16.65
		Sul	1.70

As is expected in all operations where complete control of the analysis of raw materials is not possible, swings in the analysis of the iron outside of those limits is not uncommon.

The high MgO content of the slag has had no apparent effect on its desulphurizing ability. The fact that a slightly acid slag is sufficient for proper sulphur elimi-

nation indicates that the additional fluidity imparted by the MgO may improve the ability of the slag to remove sulphur.

SUMMARY

It is the opinion of the operators at Fontana that the success of any blast furnace operation depends to a great extent upon the quality and uniformity of raw materials. Various operating techniques have been devised from time to time to improve furnace operation when using inferior raw materials, but it is believed that in the final analysis, raw material beneficiation will prove to be the key to economical and high productive furnace operation in the future. Beneficiation of coal prior to coking must also be included in the program, inasmuch as coke must be physically and chemically capable of doing its required task in the furnace. A coke must be produced which will have as uniform and as low per cent of ash and sulphur as is possible. Maintaining a uniform analysis is probably more important than maintaining extremely low but fluctuating percentages of ash and sulphur. If the analysis is uniform, although not ideal, the furnace can be operated with a minimum number of changes, and maximum production can be attained.

This same degree of uniformity should also be main-

TABLE IX — BLAST FURNACE OPERATION

Year 1947

Average daily production	Net tons	1259
Average coke consumption	Lb/Net ton	1416
Average flue dust production	Lb/Net ton	68
Average charge		
Utah ore	Per cent	48.0
Vulcan ore	Per cent	0.9
Eagle Mountain ore	Per cent	2.3
Sinter	Per cent	47.9
Manganese ore	Per cent	0.9
Total ore and sinter	Per cent	100.0
Total ore and sinter	Lb/Net ton	3221
Open hearth slag	Lb/Net ton	193
Scale	Lb/Net ton	103
Borings	Lb/Net ton	1
Total metallic charge	Lb/Net ton	3518
Stone	Lb/Net ton	201
Gravel	Lb/Net ton	1
Total charge less coke	Lb/Net ton	3720

TABLE X — BLAST FURNACE OPERATION

July 1, 1946 — July 23, 1948

Total tons produced	Net tons	904,044
Average daily production	Net tons	1,199
Average coke consumption	Lb/Net ton	1,463
Average flue dust production	Lb/Net ton	97
Slag volume	Lb/Net ton	879

Figure 9 — An unusual feature of the sinter plant is a large round table installed on the discharge end for air cooling the sinter.

tained in the physical properties of the coke. Fluctuations in strength make it difficult to determine the proper sizing of the other raw materials going into the furnace. A large strong coke will permit the use of a burden containing a large percentage of fines, while a small weak coke will require carefully sized ores. If the physical properties of the coke change radically from day to day, or even shift to shift, it is impossible to maintain the proper particle size in the furnace burden and thus furnace irregularities are magnified. It has been proved at Fontana that a furnace can be successfully operated on a relatively weak coke, if facilities are available for controlling the size of the other raw materials entering the furnace. The sizing and sintering of the available ores make it possible to charge the furnace with a very porous burden, which seems to be a necessity when using a small, weak coke.

As raw materials become more variable in size and analysis, beneficiation will become an absolute necessity, if satisfactory furnace operation is to be obtained. The operation at Fontana has definitely proved that by employing merely the very basic beneficiation processes, inferior and non-uniform raw materials can be used successfully in the production of pig iron.

DISCUSSION

PRESENTED BY

T. F. PLIMPTON, Superintendent Blast Furnace Department, Inland Steel Co., Indiana Harbor, Ind.

J. L. TATMAN, Superintendent Blast Furnace, Wheeling Steel Corp., Steubenville, South, Mingo Junction, Ohio

C. H. LENHART, General Superintendent, Iron and Steel Division, Kaiser Co., Inc., Fontana, Calif.

KENNETH C. McCUTCHEON, Assistant to Vice President in charge of Operations, Armco Steel Corp., Ashland, Ky.

L. E. RIDDLE, Consultant, Laclede-Christy Co., St. Louis, Mo.

W. W. TRINKS, Associated Engineers, Pittsburgh, Pa.

R. B. GERHARDT, United Engineers & Constructors, Inc., Bethlehem, Pa.

I. D. AKEY, Assistant Engineer of Tests, Colorado Fuel & Oil Corp., Minnequa Works, Pueblo, Colo.

J. H. BUCKHOLZ, Fuel Engineer, American Steel and Wire Co., Coke Works, Cleveland, Ohio

M. F. MORGAN, Arthur G. McKee Co., Cleveland, Ohio

T. F. Plimpton: The practice at Fontana has been a challenge to all of us. Mr. Lenhart's description of this practice has been a distinct contribution to our knowledge in a number of ways. Especially has it clarified our thinking about the value of sized and prepared iron-bearing materials in permitting satisfactory operation with a coke that normally would be thought to be very unsatisfactory.

At Inland we can testify to the fact that the Fontana coke is weaker than the coke that eastern operators are accustomed to use. While the Fontana furnace has been down for relining, some of their coke has been shipped to us. The shaking around that this coke gets in the 2,000 mile rail trip from California to Chicago is something like a long-distance tumbler test, with the result that more than 75 per cent of the coke arrives under two inches in size. Because the more friable pieces have broken in transit, the standard tumbler test made at our plant shows a stability index of about 35 per cent, which is almost twice as high as the index at Fontana.

It was interesting to us to see that 18 to 20 per cent is considered the critical stability index below which normal wind cannot be maintained. At Inland 40 per cent is considered the critical point, and we suffer wind loss whenever the average stability index gets below that. Since somewhat lower wind rate is used at Fontana than is the practice at furnaces of that size in the east, perhaps it might be found that the optimum wind rate on a furnace of a given size is proportional to some power of the tumbler index.

Before leaving the question of stability of blast furnace fuel, it may be interesting to some of you to hear of results that have been obtained recently in the Chicago district where we have been attempting to augment our coke supply with 3-in. anthracite coal, charged directly. Our experience has been limited, but it appears that in small furnaces anthracite can replace small coke with no harmful results. However, when used to replace furnace coke on a large furnace, the furnace tightens up and requires a wind cut. Other plants in the district have reported increased dust and increased tuyere burning whenever the percentage of anthracite is raised above some critical point. While the standard tumbler test was not originally designed to measure the strength of anything but coke, we have tried the test a few times on anthracite, and we have found that the stability index is quite low, between six and seven per cent, which accounts for the effects noted.

I would like to refer briefly to the relationship between coke moisture and tuyere losses. Perhaps I did not understand Mr. Lenhart correctly, but it appeared that he was attributing the unsatisfactory operation directly to the moisture in the coke. It appears to me that rather than cause and effect, this might be a case of two effects from the same cause—that is, an inferior or green coke will absorb more moisture in quenching and this inferior coke will cause tuyere burning and other ills. If this were not the case, then we would never spray our coke in bins and chutes to allay the dust, or we would never add water to the coke skips. However, it is obvious that the coke moisture in this case is a definite index of inferior coke quality, and I might say we have found the same kind of index in the amount of coke braize screened out at the furnace. The braize, of course, does not go into the furnace, but whenever the braize becomes excessive it indicates an inferior coke and it will invariably be followed by excessive tuyere

and monkey losses, a hanging furnace, or other unfortunate effects.

Mr. Lenhart told of his good fortune in having a self-fluxing sinter. His mentioning the retardation of the formation of iron silicates in the sintering plant was a new thought to me, and an important one, I believe. In addition to this benefit there should be other advantages, such as the additional voids and richer gas resulting from not having limestone calcined in the stack and a leaner bosh slag. This suggests that some of us who are not fortunate enough to have self-fluxing material to sinter, might acquire the same advantages by adding fine limestone to the sinter mix. At any rate it should be worth trying.

J. L. Tatman: You brought out a question I was going to ask and that was, relative to the high moisture coke to which Mr. Lenhart attributed the cause of furnace hanging, loss of tuyeres and coke messes. It seems to me the high moisture coke is aa indication of small coke and that it is the small coke which causes the trouble rather than the moisture content.

C. H. Lenhart: We all know and realize that coke moisture normally goes with coke strength, and we at Fontana, due to our soft friable coke, and in striving to maintain uniformity, have become too moisture-minded. Our sinter temperatures are controlled by check every 30 minutes, and we also check all our raw materials to our sinter feed by weight every 30 minutes. Our sinter temperature is checked by optical pyrometer right at the ignition point and also as it leaves the machine, allowing us to immediately make changes before we have a complete sinter bed of low quality material.

Kenneth McCutcheon: I want to ask a question about the size of the coke. Mr. Lenhart, when the moisture was high, was the size of the coke itself shown to be small?

C. H. Lenhart: Yes.

Kenneth McCutcheon: We have found that the smaller coke is higher in moisture than the larger coke from the same quench car. This would mean that with more small coke, the average moisture would be noticeably higher, as you have indicated.

L. E. Riddle: Having been in blast furnace work for more than half a century, having been at most of the furnace plants in this country, having been to Fontana several times, I am familiar with the work done and in the number of unusual obstacles not usually encountered in American blast furnace practice which they overcame.

I know of no beneficiating anywhere else in the United States or Canada to equal what they have accomplished with bore ore and coke. They improved a soft coke wonderfully by experimentation and use of low volatile coals brought from a great distance.

Some of the self fluxing ore at times was more than self fluxing; following casts where the slag was lean and acid due to irregularities in the ore, they would a few hours later get a slag that would almost give them a limeset furnace. You furnace men know how a change from an acid slag to any extremely basic one can cause irregularities and hard work.

Mr. Lenhart and his men had to overcome these things and when they screened, crushed and processed the crushed ore very efficiently with great uniformity through the sintering plant, they obtained uniform sinter. It was a wonderful accomplishment and I do not know of any other place where the ore was so irregular or where a more uniform sintered ore mixture is now obtained.

The cooling table, as he called it, at the end of the sintering machine is a new and good thing. It air cools the sinter without the addition of water and makes a porous, strong easily reducible sinter.

It was not only mechanical equipment which enabled the operators to do wonderful work, part of it was due to the way they watched every detail. For instance he did not elaborate on how they watched the moisture in the coke, how samples are taken at the skip every half hour. I have never known of any other furnace plant where they took samples at the skip even every few hours. With careless additions of water on the cooling dock this figure can vary greatly. When coke is charged by weight a careful check on moisture is essential. Yes, every little detail of their operations was watched carefully and they are to be congratulated and I commend their practice.

W. W. Trinks: Mr. Lenhart mentioned that the temperature of sintering is extremely important, because if it is set at too low a temperature the sintered material breaks to pieces when it is dumped into the furnace; and if it is sintered at too high a temperature a glassy blanket is formed around each piece of iron ore, and the iron ore sinks down very far into the furnace before the glass is melted and the ore is reduced.

Now then, how is the temperature of sintering at Fontana controlled—by what means?

Kenneth McCutcheon: You mentioned the stability test that you take on the coke and you say you take it with the standard ASTM method. What size coke do you use?

C. H. Lenhart: We use a continuous sample from which a composite sample is made at the end of each eight-hour turn, giving us three separate composite samples each twenty-four-hour period. The size that we use on the sampling is 1 in. minus.

R. B. Gerhardt: Do you expect to build a new 1200-ton furnace?

C. H. Lenhart: It will be just exactly like the other. We would like to have a larger one, but we have the wherewithal to go to work right away with a 25 ft, 6 in. hearth diameter furnace, and we figure we can save two and a half to three months of engineering work.

R. B. Gerhardt: Do you expect to make any changes to accommodate the new ore supply?

C. H. Lenhart: As far as we know, the answer is "no." We have made one complete test consisting of 35,000 tons, which, of course, is not near enough tonnage to give an over-all complete picture, but it was better than nothing, and from what we did learn, we do not look for any decided changes to be necessary.

R. B. Gerhardt: Will you duplicate the oven capacity?

C. H. Lenhart: The oven capacity problem, at this time, has not been settled.

Ivan D. Akey: I would like to make a remark that I was extremely interested in your experience with your air-cooled discharge table. At Pueblo, we have water, and as you pointed out you have a similar weather sit-

uation to ours. Freezing is quite severe in the winter time; and at any time the closest control we can get is not very good.

We also went through a little work there with respect to the work that you are doing on controlling the temperature of the sinter bed. We have found in a few instances the value of the vast amount of work you are doing with that. It has been very satisfactory at our place.

What type of control do you keep on your coke and ore ratio? Do you have an automatic system?

C. H. Lenhart: We control our coke and ore ratio manually. This check is made every 30 minutes.

Kenneth McCutcheon: Could you give us, Mr. Lenhart, the relative value of the numerous things you have done? As I see it, you have sinter and you have sized your ore, and you have controlled the sizing of it. You have cooling on your sinter, and temperature control on your sinter. You have also done some work on your coke. You said that all of those are of importance. Where would you place them relatively? For instance, the cooling of the sinter, what does that mean to you? Can you give us a little idea how you feel about it?

C. H. Lenhart: At this stage of our operating practice, I will have to admit that it would be quite a task to relatively enumerate and put our finger on any one of the many things we were forced to do as outranking any of the others. As far as sinter is concerned, in the past I have heard many arguments pro and con and now wonder whether they were all talking about the same product, so-called sinter. In the beginning at Fontana, we made a hard faced, dense sinter and immediately realized we had to work hard and fast to change it. Our first step in this direction was to set up a definite control, which we did immediately, and after a lot of experimenting, we found that our air cooled sinter not only gave us very little fines to be available for flue dust in the furnace later on, but its power of being reduced in the furnace evidently was also increased quite a bit. We started with 20 per cent on the burden and gradually worked through a cycle where we had a maximum of 68 per cent on the burden. We found out after levelling off and helping remedy some of the other variables in the over-all problem, that a 50-50 burden seemed to give us our optimum operation.

Our sinter is very porous and rather soft, requiring us to handle it almost as gently as we do our coke.

Another important factor in our operation was not only the improvement in the coke quality, and we actually made coke, but in our handling of the coke after we had it made.

The original plant consisted of two small bins containing rock ladders with an over-all capacity of 300 tons. This was enlarged and made into a surge bin with a capacity of 1200 tons. This bin is filled with a tripper conveyor, and coke is kept rolling on coke all the time. We have vibrator shakers on our feed bins in the stock yard that feed onto our belt carrying the coke to the skips. These bin doors are set so that a constant flow of coke is discharged evenly over our skip screen, which enables us to have very efficient screening.

In the ore handling, the original setup called for unloading, crushing, and then bedding the ore. This meant that when the ore was reclaimed, it had to be screened, which, during certain times of the rainy season in California during the winter, was impossible to do. This created the problem of not only charging all the fines to the furnace, but no fines were available for sintering, which was very detrimental because the ore contained quite high percentages of sulphur in a range of from 1 to 2½ per cent. This setup was changed so that now we unload, crush, screen, and then bed the ore, allowing the coarse ore for the furnace and the fines for the sinter plant. This step was very vital because our crushing and screening capacity allowed us to sinter all of our high sulphured Vulcan ore 100 per cent, it being unnecessary to charge any coarse, high sulphured Vulcan ore into the furnace.

If, at this time, I am forced to give an answer to which phase did more than any other, I think I would say the strenuous fight for uniformity and control of our raw materials from the source of origin has been of the greatest benefit. It is only natural that mechanical or design changes had to be made to facilitate this problem.

R. B. Gerhardt: Do you figure you will handle your slags as cheaply by your method as we do in the east, particularly with the second furnace?

C. H. Lenhart: Due to gravel and other aggregates being so plentiful and cheap in the far west, our slag disposal, until recently, created somewhat of a problem. There is now a rock wool plant adjacent using our slag. Also, our slag is being consumed by an asbestos products manufacturer. Our slag handling in the early days of operation without the slag pits would have been quite a problem, especially in view of operating with green furnace crews and green railroad crews and rather high slag volumes. We have found it still economical and are going to do the same with the second furnace, although there is some demand for granulated slag and a granulating pit may be installed with the second furnace.

J. H. Buckholz: What method do you use for quenching your coke and what timing cycle do you use there? I was interested in the amount of water you use and the time in which you use it.

C. H. Lenhart: I do not know the exact details as to our timing cycle and quantity of water used in coke quenching. I can say, however, that the water is measured and automatically checked every 30 minutes. The oven foreman's problem here is two-fold: first, keeping the moisture down, and secondly, preventing the rubber belts from burning.

J. L. Tatman: With these high oxygen coals from Utah, do you have any trouble coking that coal? You stated, as I recall, that the coke has been in stock for 30 days.

C. H. Lenhart: Thirty to sixty days.

J. L. Tatman: Is the coal compact in the stock pile or is it more or less in a loose condition? If the coal is not compact, this would tend to have oxidation take place and, generally speaking, oxidized coal does not make good coke.

C. H. Lenhart: We do compact our stockpile to prevent oxidation and also derive great benefits from a

blending standpoint. In the past year we found we could use 67-day old coal without losing any coke quality.

M. F. Morgan: Considerable interest has been shown and many questions have been asked about this air cooler. It was invented and installed at Kaiser's to improve the physical quality of the sinter, which I think every sintering plant should do. Their ultimate goal was to produce the kind of sinter that would work in the blast furnace, and they did it.

It has not been brought out, in this meeting, that when sinter is air cooled the thin cellular structure is annealed, which gives the sinter stability. To produce stability in the past, excess carbon is added to the sintering mixture, which makes a large pore thick cell wall sinter that will not break up into the fine sizes when quenched with water. This latter procedure jeopardizes the sinter quality which can be attributed to the way sinter is handled after it is made.

I believe one of the main reasons the sintering process has not been developed beyond its present stage can be attributed to the methods used in handling the sinter after it is discharged from the sintering machine. The operating procedure, that is necessary to produce a sinter with physical qualities that will not break up into fines when quenched with water has caused many adverse results in blast furnace practice.

The rotary cooler has made it possible to handle the cooled sinter to the blast furnace by belt conveyor, eliminating the use of water for cooling. Water is not only detrimental to the sinter, but also creates a hazardous steam and water condition at the discharge end of the sintering plant.

In my opinion, the air cooling of sinter is one of the major improvements in sintering plant practice that has been developed in the past ten years.

The second cooler has been installed at the Provo, Utah, sintering plant. This cooler is functioning with the same regularity and the results obtained are the same as those at Fontana. I think the sintering plants at Fontana, Calif., and Provo, Utah, are the only plants sintering ferrous materials that actually air cool sinter. If anyone present is interested in how to produce quality sinter, it would be well worth your time to visit these plants to see how the carbon in the sintering mixture is regulated, the temperature and quality of the sinter as it is discharged from the sintering machine, and then after it is air cooled.

In regard to temperature control on the sintering machine, it is governed by the percentage of carbon in the raw material mixture. When this mixture passes under the ignition furnace it is ignited on the top surface and as the ignited mixture moves out from under the ignition furnace, the temperature is recorded by optical pyrometers. The temperatures shown on these pyrometers indicate the percentage of carbon in the sintering mixture and makes it possible for the operator to make carbon corrections immediately instead of waiting until the sinter can be observed at the discharge end of the sintering machine.

In the first case the sinter produced would be the conventional type of sinter that is used at most blast furnace plants at the present time. This sinter is discharged from the sintering machine either into railroad cars and quenched with water or it is dropped into a pit, water quenched and handled with a clam shell bucket. If this sinter was air cooled and handled properly I believe the particle size and physical characteristics would be improved and therefore improve the blast furnace practice.

The only blast furnace plant that has operated on water cooled sinter and then changed to air cooled sinter is the one at Fontana. Mr. Lenhart stated when the furnace was using water cooled sinter the percentage of sinter in the burden was 25 per cent, which they considered was the maximum they could use. After the air cooler was installed and the sinter, made from the same raw materials, was air cooled, the sinter in the furnace burden was increased to 50 per cent. With this percentage of sinter in the burden the blast furnace produced a record monthly tonnage.

Mr. Lenhart did not mention any record furnace performance using water cooled sinter. This is the only furnace operation so far that has any operating data showing the advantages of air cooled sinter.

Kenneth McCutcheon: Mr. Morgan, suppose you would have a sintering machine without cooling wheel on it, your blast furnace would tell you about the sinter. Suppose you put a cooling wheel on there. What improvement would the blast furnace report?

M. F. Morgan: In the first place, if you had a machine that did not have the air-cooler on it, you could not put it in railroad equipment. It is not just the cooler; it is the air-cooling of sinter that I am emphasizing. You take your sintering and put it on the coke, the same as you do the coke, without quenching, and let it air-cool, and you accomplish the same thing provided you screened it afterward.

With the railroad equipment in which you have to handle your sinter, or if you drop it in the ore yard, you drop it 30 to 50 ft, and then you take it up with the ore bridge bucket; under these conditions you break every possible piece that it is possible to break in that handling. Now if you could reduce the carbon that is in your sinter and be able to let those fine cell walls anneal, you could sinter with a lot lower carbon than is standard practice that we have today.

Kenneth McCutcheon: Would it mean that you had a given percentage better result in your blast furnace? That is, how well the sinter works on the blast furnace is measured on the production you make in the coke per ton. Suppose you have a given production and a given coke per ton, and you do not have the cooling wheel. Now suppose you put a cooling wheel on and that is all you do. What results would you have?

M. F. Morgan: I think you can answer that. He had water cooling on his sinter before and the percentage he used in the furnace was 25 per cent, what they thought was Utopia for sinter. When they put the air-cooled wheel on, he found that 50 per cent was the point that gave him the best record on the blast furnace.

I do not believe he quoted any records when he was using water-cooled sinter on his blast furnace or his coke rate, did you? That is the only criterion, because his furnace and the one at Provo are the only two plants now using air-cooled sinter to my knowledge.

EFFECT OF OXYGEN ON REFRACTORIES *in the Basic Open Hearth*

By R. S. MOORE
Harbison-Walker Refractories Co.
Pittsburgh, Pa.

. . . . the use of oxygen in the open hearth results in refractory problems which will probably be solved both by further operational experience and by development of better refractories . . . .

▲ A review of the current literature on the use of oxygen in the basic open hearth furnace might lead to the conclusion that this is a very recent innovation. It is a matter of record, however, that full scale experiments with the introduction of oxygen at the burners during the melt-down and into the bath by lance to expedite carbon removal were made in a basic open hearth at the Homestead Steel Works in 1923. In the same year, lancing with oxygen was being practiced on basic electric furnace heats at the Lehigh Works. These experiments were not carried to the point where the effect upon refractories could be evaluated, possibly because the market price of liquid oxygen at the time was of the order of $200.00 per ton.

Today, twenty-five years later, the effect on refractories of the use of oxygen still cannot be evaluated with precision for the reason that the practice is far from being standardized in any respect. The present paper must be limited, therefore, to an attempt to point out relationships between certain causes and effects as observed to date and should, in all fairness, be regarded as a progress report.

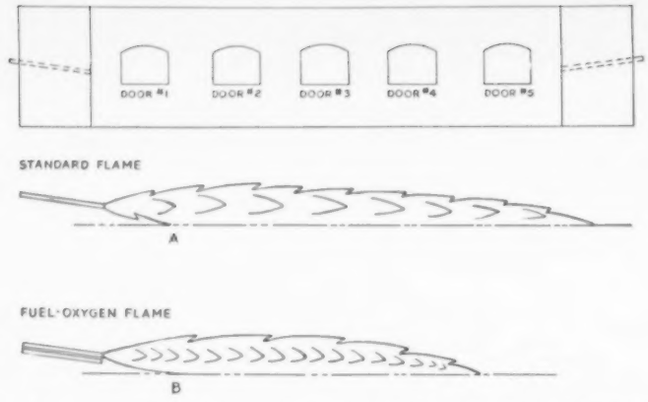
It should be pointed out that oxygen itself has not been found to have any deleterious effect upon the refractories commonly used in basic open hearth construction. Silica, fire clay and basic refractories contain only minor quantities of readily oxidizable or reducible constituents such as iron. Moreover, iron oxide does not have as severe a fluxing effect on silica in an oxidizing atmosphere as it has in a reducing atmosphere. Hence, we must look to indirect rather than direct effects of oxygen upon refractories.

Early enthusiasm prompted by preliminary reports on the results from the introduction of oxygen at or in close proximity to the burners led to many predictions as to the future of the basic open hearth. It was even suggested that all present installations would be entirely obsolete within a very few years and that, with the aid of oxygen, a one-way fired furnace without regenerators or checkers would be evolved. Present forecasts seem to be that oxygen as an aid to combustion will be confined to the interval during which the cold charge is being melted down and that regenerators will still be needed to preheat atmospheric air for combustion throughout the entire progress of the heat. It is probable, however, that in reaching a standardized practice with oxygen firing in any particular furnace, advantages will be discovered through revisions, slight though these may be, in the furnace lines with respect to roof elevation and the shaping and positioning of the knuckles and monkey walls.

In the present concept, oxygen must be regarded as a tool, the skillful handling of which must be developed by diligent and persistent practice. Roof life has been shortened by as much as 50 per cent during such practice periods but the intent in the use of oxygen is to melt down the cold charge more quickly—not to melt down roofs, which can be destroyed in a single heat without resorting to the aid of oxygen. Most shops in

The use of oxygen in the open hearth reduces the time for making a heat. Whether the result is economical depends on local production requirements and will require further experience for complete evaluation.

Presented before AISE Annual Convention, Cleveland Ohio, September 29, 1948



A flame enriched by the use of oxygen gives more efficient combustion as shown by the shorter flame length.

starting to use oxygen as an aid to combustion found that they were headed toward an abrupt—almost precipitous—drop in roof life but that as experience was gained and limits were defined and established, the trend was toward a gradual recovery. In no case to date is there a report that a return to normal roof life has been accomplished and in every case, too few oxygen heats have been made to draw broad conclusions. However, there is some indication at least that the average will level off at not more than 5 to 10 per cent below normal. It should be borne in mind that roof life cannot be measured by the life of a single roof, since roofs are subject to many other variables than only the presence or absence of added oxygen. Statistics accrue slowly at the rate of 8 to 12 weeks per normal roof campaign, and require some interpretation, particularly when few, if any, shops are able to use oxygen on all of the heats in any one campaign.

The introduction of oxygen into the bath is being accomplished by jets and by lances with attendant agitation of the molten slag. The splendid moving pictures in full color which were shown at last year's meeting made a vivid impression of the extent to which slag was blown upon the roof. Here again the new tool is now being used with a greater dexterity and, in the shop where the film was made, splashing of the slag on the roof is greatly reduced if not altogether eliminated by the expedient of using more than one jet to introduce similar quantities of oxygen at substantially lower pressures and velocities.

Supplying oxygen to the bath to lower carbon sets up exothermic reactions with resulting increased metal and slag temperatures, and increased radiation to the roof and to adjacent walls. Whether or not unconsumed oxygen bubbles through the slag and promotes combustion of unspent fuel above the bath, thus contributing further to localized zones of excessive temperature, will remain a matter for speculation until someone undertakes and publishes studies of gas samples taken at various elevations between the slag surface and the roof before, during, and after the introduction of oxygen to the bath.

Increased bath temperature alone is reported to be of doubtful value except as a means of promoting metallurgical work other than the lowering of carbon. Many open hearth operators and metallurgists have already concluded that a lesson is to be learned from bessemer converter operations, where the development of excessive temperatures by exothermic reactions is controlled by the introduction of ore or scrap to set up endothermic reactions with the accomplishment of useful metallurgical work.

Introducing oxygen to the bath does increase the concentration in the furnace atmosphere of iron oxide fume, and the fluxing effect of iron oxide on silica brick and fireclay is well known.

The manufacturer of refractories is fully aware of the fact that the use of oxygen creates new problems in the application of his product, but since these problems seem to be a long way from final definition his program of research and development work must be directed toward paralleling that of his customer, the basic open hearth operator.

As the result of the present adequate supplies of accessible raw materials, silica roof brick are remarkably cheap considering the fact that they remain rigid at normal open hearth temperatures under the very considerable load imposed by the thrust of an open hearth roof span, even when partially impregnated by iron oxide and other basic fluxes. The ultimate fusion point of chemically pure silica is 3142 F, and a silica brick to be well bonded and strong enough to withstand shipment and handling must contain several per cent of silica minerals or silicate glass of lower melting point. Hence it is not within the realm of possibility to produce a silica brick having a melting point as high as 3142 F.

The practical limit in the refractoriness of a silica brick appears to have been accomplished with the development and commercial production of the super duty silica brick. Brick of this class cannot be defined in terms of ultimate fusion point but rather in terms of limits upon the total content of fluxes. Upon being heated, the silicates contained in a silica brick soften and eventually become extremely fluid. As the temperature rises, the amount of liquid increases as additional silica is taken into solution, at first very slowly and then very rapidly, especially above 2900 F. As the amount of liquid increases, the bond between the solid particles is weakened and the liquid acts as a lubricant until the brick loses its rigidity under load.

It follows that reduction in the amount of liquid in a silica roof brick increases its temperature limit under service conditions. As manufactured under U. S. Patent No. 2,351,204, issued on June 13, 1944, super duty silica brick contains not more than 0.5 per cent of total fluxes, namely, alumina, titania, and alkalies combined. Such brick will support a load of 25 or even 50 psi under soaking heat conditions at temperatures which are 60 to 100 F higher than that required to crush an ordinary silica brick.

In one open hearth shop using approximately 300 cu ft of oxygen per gallon of tar at the burner during the meltdown with a resulting increase of 12 per cent in tons per hour and decrease of 20 per cent in fuel consumption, a single super duty silica brick roof has come within approximately 3 per cent of matching the shop average for conventional silica roofs on furnaces operated without benefit of oxygen. In this campaign, oxygen was used on about 80 per cent of the heats, an unusually high percentage.

Super duty silica brick have proven conclusively

elsewhere, with and without oxygen firing, their ability to withstand higher temperatures from whatever source, and their lower content of liquid at service temperature is known to make them more resistant to reaction and fluxing by iron oxide and other basic fluxes.

The current market price of super duty silica brick is only about 12 per cent above that for conventional silica and the cost installed in a roof is probably not more than 5 per cent greater.

The next step upward from super duty silica roof brick is a very abrupt one since there appears to be no intermediate step between super duty silica brick and basic brick of chrome-magnesite compositions for open hearth roofs. Basic refractories cost between five and six times as much per unit volume as silica brick, reflecting the difference in raw material costs.

The refractoriness of basic brick is well above present or contemplated open hearth temperatures, and they are inherently very resistant to the fluxing action of basic slags. Certain basic brick which are fired in modern tunnel kilns of improved design also have remarkable resistance to load. However, the reversible thermal expansion characteristics are quite different from those of silica brick, and their application to open hearth roofs cannot be simply a matter of substituting one type of brick for another.

Silica brick have the unusual property of expanding very little with increased temperatures in the range above a dull red heat and, although there is a steep temperature gradient from the hot face to the cold face of an open hearth roof, a substantial portion of the thickness of a silica brick roof is fully expanded. With basic brick on the other hand, expansion continues at a fairly uniform rate with increased temperature throughout the entire range of open hearth temperatures. Thus, while silica brick sprung roofs have a considerable area of fully expanded brick over which the roof thrust is distributed, in basic brick sprung roofs, the tendency is for the load to be concentrated at or near the hot face where maximum expansion has occurred and this results in pinching or buckling.

A great deal of attention is being devoted currently to the mechanics of suspending basic roof brick in such a manner that the dead load of the roof is transmitted by hanger members to a steel superstructure built off the furnace buckstays. Much credit is due to the engineers working on these problems and to the work of the leading refractories manufacturers on the development of brick specifically to meet these particular requirements. There are to date in America installations of basic ends in more than thirty open hearth furnaces in which basic brick are used throughout the port walls and in suspended arches over the ports. These installations are proving to be very successful in minimizing down time for repairs and in facilitating slag removal from the slag pockets, and are contributing greatly to the knowledge of the problems involved in suspended construction. There are also two furnaces operating currently with basic main roofs in addition to having basic slag pockets.

The discussion has been confined thus far to refractories in roofs. Most shops which have worked with oxygen use basic brick as a matter of course in front walls, in back walls if any, and in end wall bulkheads. The effect of oxygen on front walls and back walls is particularly difficult to evaluate. They are subject to mechanical hazards and other variables entirely unrelated to the effects of oxygen, and are always replaced at the end of a main roof campaign even though they might serve for a somewhat longer interval.

It must be recognized, however, that an increased rate of roof consumption must have an adverse effect upon basic front walls and back walls as the result of the increased rate at which silica from the roof runs down over them.

In the opinion of the majority of operators who have had experience with oxygen, its effect on basic end wall bulkheads is not particularly significant. There remains

The open hearth shop is an *important* user of refractories.

to be evaluated the effect of the use of oxygen upon checkers and regenerator chambers. Higher regenerator temperatures may or may not be a necessary corollary when sufficient experience has taught the optimum time interval between reversals.

In conclusion, it should be pointed out that since the first open hearth rebuilt, it has been the aim to construct a "One Hoss Shay" which would serve satisfactorily for a reasonable interval and then require replacement of the fully spent structural materials all at one time. Each new development in open hearth practice, in the engineering of furnace construction, and in the improvements in available refractory materials has had the effect of transferring the zones of most critical wear from one section of the furnace to another. The bolstering of these points of weakness has been and will continue to be a matter of trial and error directed by judgments based upon a background of engineering principles and the interpretation of data obtained in the ceramic laboratories.

DISCUSSION

PRESENTED BY

T. H. HARLEY, Ceramic Engineer, Bethlehem Steel Co., Johnstown, Pa.

E. C. McDONALD, Chief Combustion Engineer, Corrigan McKinney Div., Republic Steel Corp., Cleveland, Ohio

R. S. MOORE, Harbison-Walker Refractories Co., Pittsburgh, Pa.

P. F. KINYOUN, Combustion Engineer, Bethlehem Steel Co., Lackawanna, N. Y.

T. H. Harley: I have a few comments concerning the use of oxygen in a furnace at Johnstown. There were 187 heats made on this campaign at the Johnstown furnace, of which approximately 30 per cent were made using oxygen.

Our experience with this furnace does not corroborate Mr. Moore's roof data that he has presented, in that with the super-duty silica brick roof we obtained very little wear on this brick. We used the 13-in. valley, 18-in. rib roof in our furnace, and after this campaign was completed, there were between 10 and 11 inches remaining on the original 13-in. roof. This roof was in excellent condition, but I presume that each shop naturally will have a difference in their roof life experience.

Data on our front wall costs indicated that our costs were almost doubled. It is a fact, however, that we took exceptional care of the front. Whenever there was a slight amount of damage to the front, we immediately started a repair, employing all basic brick, whereas normally we use a considerable number of silica brick. Consequently our front wall life is not truly representative of what might be obtained, and the costs were higher than normal.

There was approximately a 35 per cent increase in repairs to silica end walls above floor level.

E. C. McDonald: I am particularly interested in your remarks on improvement being made in one plant using oxygen in the bath. As you stated this shop drastically reduced the splash by using multiple jets. What improvement was made in roof life by injecting the same quantity of oxygen into a greater area of bath? Also, is the shop under discussion using super-duty brick? It is my opinion your short treatment of the subject of bath injection of oxygen may lead those not familiar with subject to believe all the problems have been solved. Do you care to add any discussion that will clarify this point?

R. S. Moore: The figures on roof life have not yet been accumulated. They are very confident in their observations that the almost total elimination of splash, the splash that we saw in the colored films last year which brought so clearly to all of us to what an extent the vicious slag is working on the roof, will give great savings.

The way they are doing it, of course, is not by reducing the amount of oxygen, but by using approximately the same amount of oxygen, and using it through more than one jet at lower velocities and lower pressures.

They are using super-duty brick. I do not say that super-duty brick have contributed to what I am reporting. I am mentioning it simply as a physical observation of the splash of slags.

P. F. Kinyoun: Mr. Moore made the statement that super-duty silica brick in a furnace using oxygen gave a life of within 3 per cent of standard silica brick when not using oxygen. I would be interested to know what the comparison is when using super-duty silica brick without oxygen, as compared to standard silica brick without oxygen.

R. S. Moore: Without oxygen the super-duty brick have demonstrated their economy in many open hearth shops. The opinion is not unanimous in that respect, but there have been many papers in the literature by open hearth operators who have definitely concluded that the super-duty silica brick justify their higher first cost in normal operation without oxygen.

I might also add that until very recently that type of brick has been available only in very limited quantities. The increased availability of that brick through improved technology, control and so on, is just now reaching the point where it will meet the demand.

P. F. Kinyoun: Mr. Moore said that the oxygen used, equaled 300 cu ft per gallon. On the basis of a furnace, for example, using 300 gallons per hour, the oxygen would be 90,000 cfhr or 1500 cu ft per min. This rate of oxygen consumption seems rather high, in fact higher than I am familiar with. I would be interested to know what the rate per minute is and how much oxygen was consumed per ton on a furnace producing 200 net tons per heat.

R. S. Moore: I believe it was of the order of 75,000 cu ft per heat.

P. F. Kinyoun: At that rate, oxygen was used for less than one hour.

R. S. Moore: During the melt down, yes. I cannot attempt to speak for the open hearth operators as to what is good and what is not good practice in the use of oxygen. There must be some open hearth operators here who could comment on that from the background of experience.

P. F. Kinyoun: It is a high rate for a short period; it being a higher rate and a shorter period than I am familiar with.

ASSOCIATION OF IRON AND STEEL ENGINEERS

Specifications for

ELECTRIC OVERHEAD TRAVELING CRANES

FOR STEEL MILL SERVICE

AISE STANDARD No.
REVISED MAY 1, 1949

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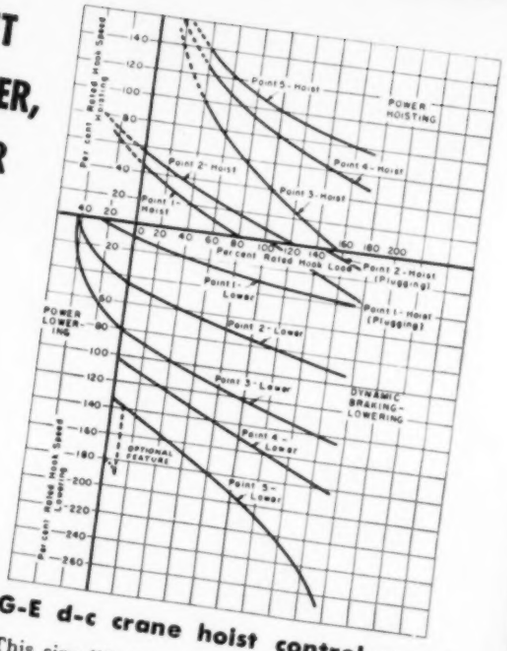

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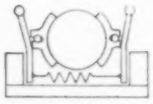

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ASSOCIATION OF IRON AND STEEL ENGINEERS

Specifications for

ELECTRIC OVERHEAD TRAVELING CRANES FOR STEEL MILL SERVICE

AISE STANDARD No. 6

REVISED MAY 1, 1949

Foreword by F. W. Cramer

▲ SINCE 1910, the Association of Iron and Steel Engineers has sponsored a series of specifications for electric overhead traveling cranes for steel mill service. Such specifications have been required, since it has been long recognized that steel mill cranes must be of strong, rugged construction for 24-hour service, 7 days a week. These specifications, which were originally issued in 1910, have been reissued in 1916, 1919, 1929, 1938, 1942, and again in 1949.

It is believed that this present specification represents the most modern available data on overhead traveling cranes. Credit for this accomplishment is due only to the unremitting work of the committee which has been composed of steel mill engineers, crane manufacturers and crane equipment manufacturers. The writer, who acted as chairman of the crane committee, acknowledges with thanks cooperation of the following members of the crane committee.

James Farrington, Electrical Superintendent, Wheeling Steel Corp., Steubenville, Ohio.

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In the 1942 revision of the crane specifications, extensive changes were made in the girder and structural design sections. These sections were brought up to date as a result of a two year program of research work carried out by the Association of Iron and Steel Engineers at the Fritz Engineering Laboratory of Lehigh University by Bruce Johnston, Assistant Director of the laboratory and I. E. Madsen, Research Engineer. Details of this work have been reported in "Report of Crane Girder Tests," by I. E. Madsen, 1941 AISE Yearbook, Page 531. The conclusions and data from this work formed the basic data in the revised specification. The present revision incorporates only minor changes in the structural sections. However, major changes have been incorporated in the mechanical and electrical sections which are discussed briefly as follows:

In the mechanical section an entirely new procedure has been set up for specifying crane gears. This procedure is based on the present practices and recommendations of the American Gear Manufacturers Association, and the specification is based on the work of a committee of the AGMA headed up by Mr. C. R. Burrell and Mr. F. Richardz. In the revised gear specification, the allowable horsepower on any pair of gears is based on a minimum set by either a strength or durability requirement. These requirements in turn are based on the hardness of the gear as given by the Brinell hardness test. This thus opens the field to most types of gears and the allowable load is thus matched against the actual quality of the gear.

Other changes in the mechanical specifications include major revisions to the roller bearing tables. These tables have been brought up to date to take into account present ratings of bearings, which are listed in accordance with manufacturers recommendations. These tables also include a variable bore which is an addition to the old specification. In the old specification, the bore was made uniform for a particular box load regardless of the service of the crane. Thus, since many bearings are only made in a few widths, one often is required to use the same bearing for both light and heavy duty service. In the present specification for light duty service, it is possible to use a smaller bore and smaller bearing by taking advantage of the variable column. Other changes in the mechanical standards include the addition of standards for solid couplings, crane wheels and sheaves. These last three are standards which were adopted by the AISE since the last revision and have been incorporated in these crane specifications.

Also, the 135 pound per yard section has been added to the section on crane rails. Thus three rails designed for crane usage, the 105, 135 and 175 pound sections are now available.

In the electrical section, the motor specifications have been extensively revised to give a new method of selecting motors. This method is based on characteristic curves of the motor and attempts to select the motor to meet its actual load. Gearing is tied in with the motor speed for the actual motor load. Improper gearing has been the cause of much trouble on older cranes, inasmuch as gearing was improperly selected for high top speed which often results in bad acceleration and heating characteristics. In the old specifications, motors were based on the friction horsepower for top speed multiplied by arbitrary factors. The present specification formulae base motor horsepower on that which is necessary to give the required acceleration as well as that needed to overcome frictional forces at top speed. Inasmuch as the horsepower required for acceleration peaks may be many times that required to maintain top speed it should be the governing factor in the selection of the motor. Heating during acceleration peaks has also been the cause of many motor failures. By properly selecting the gear ratio, better acceleration characteristics are given and less overall heating is produced. In addition, since most of the movements of a crane in a plant are short, the acceleration time for a particular cycle is the critical item, and therefore, a given duty cycle will be performed in shorter time with a crane which has the correct acceleration characteristics, even though its top speed may be less than that of another crane whose gearing has been selected for speed rather than for acceleration. The purchaser must furnish on his information sheets the acceleration required.

Consideration of these items means that more information will have to be given to the control manufacturer in order to get the correct design of resistance steps, but the result will be less heating in the motor and a better controlled crane.

Several other projects, underway at the present time by the AISE, namely, a specification on crane limit switches, crane motor brakes, and crane wiring, have not been completed enough to be included in these crane specifications. These will, however, be issued later as supplementary specifications and incorporated in the crane specification when they are next revised.

The user of these specifications should also be sure to look over the appendix. In here are given reasons, explanations and development of many of the clauses in the actual specification.

In compiling a standard of this nature, discrepancies, omissions, etc. may be unavoidable regardless of the care taken in preparing the material. Also future developments may make obsolete present specification requirements. It is the policy of the Association of Iron and Steel Engineers to revise and modernize all standards at reasonable intervals. Suggestions, criticisms, or revisions on this work are welcomed and will be given due consideration in next preparing the specifications.

AISE CRANE SPECIFICATIONS

General

1. Explanation:

A. These specifications cover heavy duty, mill type, overhead traveling cranes. All cranes for special service such as charging, pit, stripper, ladle, gantry cranes, or ore bridges, etc., shall so far as possible comply with these specifications. The bridge design clauses in these specifications apply primarily to box girders. For cranes having a span of 100 ft or more, the use of latticed welded girders, or a combination of single web main girder and latticed outrigger girder made of high tensile steel may be considered at the option of the purchaser to obtain a reduction in weight of the bridge.

2. Specifications:

A. This specification shall be known as the Specifications for Electric Overhead Traveling Cranes, AISE Standard No. 6. It shall be referred to in all contracts as such and shall form part of such contracts when so stated, whether attached to same or not. Builder's specification shall be known as contractor's specification. These specifications shall take precedence over contractor's specifications and shall be strictly adhered to, and no other specifications or understandings will be considered unless agreed to in writing.

B. Sheets issued by the purchaser stating sizes, special features, requirements, etc., shall be known as "purchaser's information sheets." Where the requirements of these information sheets differ from specification, the former shall take precedence.

C. Sheets to be filled in by bidder showing specific data in regard to apparatus he proposes to furnish, shall be known as "contractor's information sheets."

D. Where contract covers a number of cranes, this specification shall apply to each and every one.

E. In addition to specifications furnished with proposition, contractor shall furnish the required number of copies of his specification for the purchaser's file.

3. Note to Bidder:

A. Bidder shall submit the number of proposals called for on the information sheets, stating therein the price (as specified on questionnaire) for which he, as contractor, will agree to furnish the work as covered by these specifications and information sheets.

B. Bidder shall furnish with each copy of the proposal:

1. Complete specifications covering the work proposed to be furnished.
2. The data called for on questionnaire accompanying and forming part of these specifications.

C. The purchaser reserves the right to reject any or all bids.

4. Guarantee:

A. Contractor shall guarantee that the work furnished under this contract will perform the required functions according to specifications and information sheets, and shall agree to pay all costs for furnishing any part or parts of the work furnished under this contract which may prove defective within one year after placing in regular operation.

5. Patents:

A. The contractor, in case of work designed or specified by him and even though approved by purchaser, shall and will indemnify, save harmless, and defend the purchaser from and against any and all suits, actions, legal proceedings, claims, demands, damages, costs, expenses, and attorney's fees incident to any infringement, or to any claimed infringement of any patent or patents in any way relating to or connected with the work or any part thereof.

B. In case a permanent injunction is secured preventing the purchaser from operating the crane as specified, the contractor shall, at his own expense, either:

1. Procure the right for the purchaser to continue using said crane;
2. Modify said crane so as to make it non-infringing — it being understood that such modification must meet with the approval of the purchaser, and must be of such nature as in the judgment of the purchaser will not impair the efficiency or cost of operating such work; or
3. Take back the work, and refund the purchase price for the crane.

6. Changes or Additions:

A. Purchaser reserves the right to make such changes in specifications or specific information as may be necessary after contract is signed.

B. Any difference in cost resulting from such changes shall be agreed upon before work is begun on same.

7. Erection (Including assembly, installation, and starting):

A. Work shall be erected entirely by contractor, or by purchaser, or erected or started under the supervision of contractor's superintendent, whichever is specified on information sheets. So far as is feasible, all work shall be shipped assembled in sections convenient for erection. In any case, contractor shall pay the cost of all fitting or changes necessary for proper functioning of the work.

B. Where erection is required by contractor or purchaser, all work shall be performed by party specified without recourse to the other party.

C. Where erection by the contractor is required, he shall be responsible for unloading, storing and protecting from the weather all equipment, materials, etc., and shall also be responsible for demurrage accrued on cars due to his failure to unload them within the free time.

D. Where erection under supervision of contractor is required, the contractor shall furnish the purchaser, on terms of payment agreed upon, a competent man to superintend the complete erection of the work. Purchaser will furnish all other required labor and tools. The superintendent of erection shall arrange that the erecting crew will be kept employed to the best advantage.

E. Where crane is to be started under contractor's supervision, the contractor shall furnish the purchaser, on terms of payment agreed upon, a competent man to superintend such starting.

F. After erection of the work is finished, the contractor shall promptly remove from the premises everything brought in by him which does not pertain to the completed job, leaving the premises clean.

8. Test and Acceptance:

A. Tests shall be made as specified on information sheets; otherwise, manufacturer's standard tests shall be made. In either case, the purchaser shall be notified sufficiently in advance, so that he may be represented at all tests.

B. Acceptance shall be subject to compliance with these specifications and information sheets, to be determined by inspection after delivery, by results of tests above required, and upon the approval of purchaser's representative.

C. In case of disagreement between contractor and purchaser's representative in regard to the interpretation of any specification or the compliance of the apparatus furnished with the requirements of this specification, the question shall be submitted to the engineering department of the purchasing company for decision.

D. If the crane does not comply with this specification, as modified by purchaser's special requirements, the contractor shall be notified to that effect and shall be required to make apparatus meet the specification as quickly as possible. Contractor shall proceed with the work within ten days from date of such notice, and if he fails to do so within the time specified, purchaser reserves the right to make crane comply with the specification at the expense of the contractor.

9. Workmanship, Material, and Inspection:

A. Workmanship and material shall be first class in every respect, and subject to the inspection of the purchaser's representative at all times.

10. Interchangeability:

A. All like parts on apparatus furnished or on duplicate apparatus are to be interchangeable.

11. Accessibility:

A. All working parts shall be arranged for convenient operation, inspection, lubrication, repairs, and ease of replacement.

12. Painting:

A. All work shall be thoroughly cleaned of all loose mill scale, rust, and foreign matter and then given two shop coats of specified or approved paint. All parts inaccessible after assembling, unless otherwise specified by purchaser, shall be well painted before assembling, except that riveted or welded work whose surfaces come into contact are not to be painted. Interior of all gear housings shall be painted with one coat of oil-resisting enamel.

B. The color and quality of the paint shall be as specified on the information sheets.

13. Safety Devices:

A. All machinery or equipment furnished under this contract must be equipped by contractor with all proper safety devices and clearances to comply with the laws of the state and municipality in which it will be installed, the purchaser's safety requirements pertinent thereto, and, if stated on the purchaser's information sheets, any safety requirements peculiar to the purchaser's plant involved.

14. Clearances:

A. Clearance between any part of the crane, building column, roof chord, or other stationary structure shall be not less than that shown on sketch accompanying the information sheets.

15. Materials and Factor of Safety:

A. Plain cast iron shall not be used for any parts of the crane except for plain counter-weights and collector shoes. Alloy cast iron may be used for line shaft bearing housings, anti-friction bearing cartridges, brake wheels, end caps and drums. No wood or other combustible material shall be used, except for collector staffs and conductor bar bracket supports, unless specifically approved by the purchaser.

B. Ordinary structural steel shall conform with the latest revision of ASTM Standard Specifications A-7. Low alloy structural steels shall have a composition conducive to weldability, and shall conform with the latest ASTM Specification for Low-Alloy Structural Steel, A-242.

C. The following factors of safety under maximum working load not including impact, based on the *yield point* of the material used, shall be used in the design of the crane, unless otherwise specified:

1. All parts subject to reversal of stresses and rough usage including hooks, sheave blocks, bridge and trolley drives, and complete hoisting mechanism, 4.0. Ladle hooks will be covered by appropriate AISE ladle hook specification.
2. Trolley frames and structural steel parts with non-reversal of stress, not including bridge girders, 2.5.
3. Bridge girders — See bridge girder clause, No. 17.

D. The factor of safety to be used in the design of welds shall be 4 for bridge girders and 5 for all other parts based on the design ultimate strength of the welds.

E. Wire hoisting ropes shall have a factor of safety of not less than 5 based on the breaking strength as given by the rope manufacturer for the size and grade of rope used.

F. When drums and housings are made of cast iron, the minimum tensile strength of the iron shall be 35,000 psi, and shall conform with ASTM Standard A-48 — Class 35, as a minimum requirement.

Structural Design

16. Welded Construction:

A. All welding shall be in accordance with the specifications and standards of the American Welding Society, unless specified otherwise.

B. Welding symbols on drawings shall be in accordance with the latest standard conventions of the American Welding Society.

17. Girders and Bridge Structures:

A. Crane girders shall be proportioned for the following loads and forces in addition to the dead weight of the complete crane and trolley.

1. Lifted load:
   a. The maximum working load shall be as specified on the information sheets. This load is understood to be the load on the crane hooks and does not include the weight of special hooks or lifting beam which are furnished by the contractor.
2. Impact:
   a. For runway rails, whose joints are smooth, the impact value on the bridge shall be taken as follows:
   b. For grab buckets and magnet cranes, the impact value shall be taken as 50 per cent of the maximum working load. For all other cranes the impact value shall be 0.5 per cent of the maximum working load for each foot per minute full load hoisting speed, but is in no case to be less than 20 per cent.
3. Lateral forces:
   a. These forces result from the acceleration or deceleration in the movement of the crane along the runway, and shall be considered as 20 per cent of the total weight of the crane minus the trucks, plus 20 per cent of the maximum working load, multiplied by the ratio of the number of driven wheels to the total number of wheels. The trolley and load are to be located so as to produce maximum moment or shear on the girders. The moment of inertia of the whole box girder section about the vertical axis shall be used in calculating the stresses due to lateral forces. The total lateral load shall be equally divided between both girders.
   b. If the girders and end ties (or the girders and end trucks of 4-wheel cranes) be designed so as to form a rigid frame, lateral end fixity may be considered in the design and the stresses due to lateral forces at the center of the girder may be taken as ¾ of the stresses which would be obtained if no end fixity were considered.
4. Torsional forces:
   a. The loads and forces creating torsional stress in the girders are:
      1. Starting and stopping of the bridge drive motor. The twisting moment shall be considered as the starting torque of the bridge motor at 200 per cent of full load current (1 hour rating) multiplied by the gear ratio between the motor and the line shaft.
      2. Overhanging loads on side of girder, such as footwalk, bridge drive, collector bars, cab, controls, etc. These moments shall be taken as their respective weights multiplied by horizontal distances between the respective centers of gravity and the center of gravity of the girder section.
      3. Lateral forces acting eccentric to the horizontal neutral axis of the girder. The twisting moments shall be considered as these forces multiplied by the vertical distance between center line of force and the center of gravity of the girder.

b. The total twisting moment shall be the algebraic sum of the moments resulting from loads in paragraphs 17-A-4-a-1, 17-A-4-a-2, and 17-A-4-a-3. Secondary torsional stresses caused by eccentricity as a result of load deflections will not be considered.

c. The maximum torsional unit shear in pounds per square inch shall be computed from the following formula for box girders:

$$V = \frac{M}{2AT}$$

where A = area of box bounded by center lines of web and cover plates.

T = total thickness of plate or plates in section of box for which the stress is computed (for web, this will be web thickness).

M = twisting moment in inch pounds at the section considered. It is not necessarily equal to the total torque on the girder. When the twisting moment is applied to the center of the girder, the resisting torque on each side of the section is equal to one-half of the total twisting moment; and when the twisting moment is not applied to the center, the torque taken at each section of straight girders is computed in the same manner as the shear due to vertical load at that section would be computed.

5. Wind load on outside service cranes:

a. The wind load shall be taken at 30 pounds per square foot of the projected area.

B. If the purchaser so specifies on the information sheet, a stress sheet showing the stresses from each of these loads and forces shall be included with the prints submitted by the contractor to the purchaser for approval of design.

C. For box girders, the combined bending moment stresses shall be taken as the larger of:

1. Sum of maximum stresses due to the dead load, weight of trolley, lifted load, and impact.

2. Sum of maximum stresses due to the dead load, weight of trolley, lifted load, and the lateral forces.

D. For box girders, the combined shear shall be taken as the sum of the maximum shears due to the dead load, weight of trolley, lifted load, impact and torsion.

E. Stress due to wind may be neglected if such stress does not increase the total combined stress more than 25 per cent.

F. Members subject to reversal of stress shall be proportioned as follows:

1. Determine the resultant tensile stress and the resultant compressive stress and increase each by 50 per cent of the smaller, then proportion the member so that it will be capable of resisting either increased resultant stress. Connections shall be proportioned for the sum of the stresses.

G. The bridge structure including the end tie and end connection, and excluding end trucks and trolley, shall be proportioned in accordance with the following stresses in psi:

	ASTM A-7-46 structural steel	Low alloy structural steel
1. Minimum ultimate tensile strength	60,000	70,000
2. Minimum yield point	33,000	50,000
3. Unit stress in tension on net section not to exceed	18,000	27,000
4. L/B not to exceed:		
a. Riveted box girders	65	65
b. Welded box girders	60	60
5. Compressive unit stress for top flange of box girders (when W/T does not exceed 40 for carbon structural steel or 33 in the case of low alloy structural steel) shall not exceed	17,000	25,000
or the stress given by the formula	$f_c = \frac{0.673\ E\sqrt{I_2 J}}{SL}$	$f_c = \frac{0.673\ E\sqrt{I_2 J}}{SL}$
6. When W/T exceeds 40 for carbon structural steel, or 33 in the case of low alloy steel, the compressive stress shall not exceed	$f_c = 27{,}200{,}000\left(\frac{T}{W}\right)^2$	$f_c = 27{,}200{,}000\left(\frac{T}{W}\right)^2$
Note: These values are given in Table 17-I.		
7. Compressive unit stress for axially loaded columns and struts shall not exceed	$15{,}000 - 0.25\left(\frac{L}{R}\right)^2$	$22{,}500 - 0.57\left(\frac{L}{R}\right)^2$
8. L/R for axially loaded columns and struts shall not exceed	120	120
9. Maximum allowable unit shear (V) in web plates	12,000	18,000
10. Unless vertical stiffeners are used, H/T shall not exceed	$\frac{6600}{\sqrt{V}}$	$\frac{6600}{\sqrt{V}}$
Note: These values are given in Table 17-II.		
11. Spacing of vertical stiffeners in inches when required by the foregoing shall not exceed	$\frac{10{,}500\ T}{\sqrt{V}}$	$\frac{10{,}500\ T}{\sqrt{V}}$
Note: These values are given in Table 17-III.		
12. Unless longitudinal stiffeners are used, H/T shall not exceed	$72\ (K+1)\ \frac{17{,}000}{f_c}$	$60\ (K+1)\ \frac{25{,}000}{f_c}$
This formula applies when K varies from 1.6 to 0.6.		
Note: These values are given in Table 17-IV.		
13. If H/T exceeds ratios given by 17-G-12, the webs must be stiffened with adequate and sufficient longitudinal stiffeners. When one longitudinal stiffener is used and placed as specified, (17-G-23), the maximum H/T ratio may be doubled. When two longitudinal stiffeners are used and placed as specified, (17-G-23), the maximum H/T ratio may be tripled.		

Notation used in formulae:

L = span of crane in inches.
B = distance between webs in inches.
T = thickness of web or flange in inches.
H = clear depth of web — toe to toe of vertical legs of flange angles for riveted construction.
— back to back of cover plates for welded construction.
V = unit shear in web plates.
R = radius of gyration.
f_c = maximum compressive stress in member considered.
f_t = tension stress acting concurrently with f_c in member.
K = f_t/f_c.
S = vertical section modulus in inches^3.
E = modulus of elasticity in pounds per square inch.
I_2 = moment of inertia of whole girder section about vertical axis in inches.
J = torsional constant in inches^4 (See appendix for formula).
W = clear width of top flange — distance between inside rivets for riveted construction — distance between webs for welded construction.

TABLE 17-I

Maximum Clear Widths of Cover Plate

Compressive unit stress in top cover plate, psi	Maximum clear width of cover plate in inches for following thicknesses of compression cover plate												
	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
8,000	14	18	22	25	29	33	36	40	43	47	51	54	58
9,000	14	17	21	24	27	31	34	38	41	45	48	51	55
10,000	13	16	19	23	26	29	32	36	39	42	45	49	52
11,000	12	16	19	22	25	28	31	34	37	40	44	47	50
12,000	12	15	18	21	24	27	30	33	36	39	42	45	48
13,000	11	14	17	20	23	26	29	32	34	37	40	43	46
14,000	11	14	16	19	22	25	27	30	33	36	38	41	44
15,000	11	13	16	19	21	24	27	30	32	35	37	40	43
16,000	10	13	15	18	21	23	26	28	31	33	36	38	41
17,000	10	12	15	17	20	22	25	27	30	32	35	37	40
18,000	10	12	15	17	20	22	24	27	29	32	34	36	39
19,000	9	12	14	17	19	21	24	26	28	31	33	36	38
20,000	9	12	14	16	18	21	23	25	28	30	32	35	37
21,000	9	11	13	16	18	20	22	25	27	29	31	34	36
22,000	9	11	13	15	17	20	22	24	26	28	31	33	35
23,000	8	11	13	15	17	19	21	23	25	28	30	32	34
24,000	8	11	13	15	17	19	21	23	25	28	30	32	34
25,000	8	10	12	14	16	18	21	23	25	27	29	31	33

Above computed from $f_c = 27{,}200{,}000 \left(\frac{T}{W}\right)^2$

TABLE 17-II

Limiting Clear Depth of Girder for Omission of Vertical Stiffeners

Thickness of web plate, in.	Clear depth of web in inches for the following values of unit shear in web, psi																	
	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000
1/4	52	37	30	26	23	21	20	18	17	17	16	15	15	14	13	13	12	12
5/16	65	46	37	32	29	27	25	23	22	21	20	18	18	17	17	16	16	15
3/8	78	55	45	39	35	32	30	28	26	25	24	22	22	21	20	19	19	18
7/16	91	64	53	45	41	37	34	32	30	29	27	26	25	24	24	23	22	21
1/2	105	74	60	52	47	43	39	37	35	33	31	30	29	28	27	26	25	24
9/16	117	83	68	58	52	48	44	41	39	37	35	33	32	31	30	29	28	27
5/8	131	92	75	65	58	53	49	46	43	41	39	37	36	35	34	33	32	31
11/16	144	102	83	71	64	59	54	51	48	45	43	41	40	38	37	36	35	34
3/4	157	111	90	78	70	64	59	55	52	49	47	45	43	42	40	39	38	37
13/16	170	120	98	84	76	69	64	60	56	54	51	48	47	45	44	42	41	40
7/8	183	129	105	91	82	75	69	65	61	58	55	52	50	48	47	45	44	43
15/16	196	139	113	98	87	80	74	69	65	62	59	56	54	52	50	49	47	46
1	209	148	120	104	93	85	79	74	69	66	63	60	58	56	54	52	51	49

Above computed from $\frac{H}{T} = \frac{6600}{\sqrt{V}}$

TABLE 17-III

Maximum Spacing of Vertical Stiffeners on Girders without Horizontal Stiffeners

Thickness of web plate, in.	Stiffener spacing in inches, for the following values of unit shear in web, psi																	
	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000
1/4	83	58	48	41	37	34	31	29	28	26	25	24	23	22	21	21	20	19
5/16	104	73	60	52	46	42	39	37	34	33	31	30	29	27	27	26	25	24
3/8	125	88	72	62	56	51	47	44	41	39	37	36	34	33	32	31	30	29
7/16		102	84	72	65	59	55	51	48	46	44	42	40	38	37	36	35	34
1/2		117	96	83	74	68	63	59	55	52	50	48	46	44	43	41	40	39
9/16			108	93	83	76	71	66	62	59	56	54	52	49	48	46	45	44
5/8			120	104	93	85	78	73	69	66	62	60	57	55	54	52	50	49
11/16				114	102	93	86	81	74	72	68	66	63	61	59	57	55	54
3/4					111	102	94	88	83	79	75	72	69	66	64	62	60	58
13/16						110	102	95	90	85	81	77	74	71	69	67	65	63
7/8							110	103	97	92	87	83	80	77	75	73	70	68
15/16								110	104	98	94	89	86	82	80	78	75	73
1									111	105	100	95	92	88	86	83	80	78

Above computed from $d = \frac{10500\ T}{\sqrt{V}}$

TABLE 17-IV

Maximum Allowable H/T Ratios on Girders without Horizontal Stiffeners

Compressive unit stress at toe of flange angles, psi	Maximum H/T ratios on girder webs with no horizontal stiffeners for following K values										
	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6
8,000	168	178	189	200	210	220	231	241	252	262	273
9,000	158	168	178	188	198	208	218	228	238	248	258
10,000	151	160	169	179	188	198	208	216	226	235	244
11,000	143	152	161	170	179	188	197	206	215	224	233
12,000	138	146	155	163	172	181	189	198	206	215	224
13,000	132	140	148	157	165	173	182	190	198	206	215
14,000	127	135	143	151	159	167	175	183	191	199	207
15,000	122	130	137	145	153	161	168	176	184	191	199
16,000	118	126	133	141	148	155	163	170	178	185	192
17,000	115	122	130	137	144	151	158	165	173	180	187
18,000	112	119	126	133	140	147	154	161	168	175	182
19,000	109	116	122	129	136	143	150	156	163	170	177
20,000	106	113	120	126	133	140	146	153	160	166	173
21,000	103	110	116	123	129	136	142	148	155	161	168
22,000	101	108	114	121	127	133	140	146	152	158	165
23,000	99	105	111	118	124	130	137	143	149	155	161
24,000	97	103	109	115	121	127	133	139	145	151	157
25,000	95	101	107	113	119	125	131	137	143	149	155

Above computed from $\frac{H}{T} = 72\,(K+1)\sqrt{\frac{17000}{f_c}}$

or $\frac{H}{T} = 60\,(K+1)\sqrt{\frac{25000}{f_c}}$ $\qquad K = \frac{f_t}{f_c}$

17-G (Cont.)

	ASTM A-141 structural rivet steel	ASTM A-195 high strength structural rivet steel
14. Shearing:		
a. Rivets	13,500	18,000
b. Pins and turned bolts in reamed or drilled holes	13,500	.....
c. Unfinished bolts	9,000	.....
15. Bearing:		
a. Rivets in single shear on:		
1. Carbon steel	24,000	24,000
2. High tensile steels	24,000	32,000
b. Rivets in double shear on:		
1. Carbon steel	30,000	30,000
2. High tensile steels	30,000	40,000
3. Pins and turned bolts in reamed or drilled holes	30,000	.....
4. Unfinished bolts	16,000	.....

16. The allowable unit weld stresses to use in design are given in Table 17-V.

17. The bearing stress of parts in contact such as stiffeners and flange plates shall not exceed 27,000 pounds per square inch for milled surfaces and 24,000 pounds per square inch for unfinished surfaces.

18. For stress carrying members, the spaces between intermittent welds shall be not greater than 10 times the thickness of the lighter section joined by the welds for members in compression, nor more than 14 times the thickness of the lighter section for members in tension. The length of any segment of intermittent weld shall be not less than 4 times the weld size with a minimum of 2 inches.

19. Rivets shall be spaced not more than 16 times the thickness of the lighter outside section, or more than 6 inches on centers.

20. The width of the outstanding legs of angles in compression (except where reinforced by plate) shall not exceed $12\,T\sqrt{\frac{17,000}{f_c}}$ and shall not exceed 16 T.

21. Unstiffened cover plates shall not extend more than 6 inches nor more than $12\,T\sqrt{\frac{17,000}{f_c}}$, where

TABLE 17-V

Design Stresses in Fillet Welds

Length of leg of fillet weld, in. ("weld size")	Working strength, lb per linear inch of one fillet	
	Factor of safety based on design ultimate strength	
	4	5
1/8	940	750
3/16	1410	1120
1/4	1870	1500
5/16	2340	1870
3/8	2810	2250
7/16	3280	2620
1/2	3750	3000
9/16	4220	3370
5/8	4690	3710
11/16	5160	4120
3/4	5630	4500
13/16	6090	4870
7/8	6560	5250
15/16	7030	5620
1	7500	6000
1 1/8	8440	6750
1 1/4	9370	7500

T is the thickness of the thinnest plate, beyond the outer row of rivets connecting them to the angles for riveted construction, or the center of the web plates for welded construction.

22. The outstanding legs of vertical stiffeners shall not extend more than 16 times the thickness of the leg. The outstanding leg of horizontal stiffeners shall not exceed $12\ T\sqrt{\frac{17{,}000}{f_c}}$ where f_c is the compression stress in the stiffener.

23. When one longitudinal stiffener is used on girder webs, it shall be placed 21 per cent of the clear depth of the web from the unstiffened compression edge. When two longitudinal stiffeners are used, these distances are 12.5 per cent and 28 per cent of the clear depth of the web from the unstiffened compression edge.

24. The required radii of gyration of horizontal stiffeners are to be computed from the formula in Table 17-VI with the appropriate constant selected from the table.

25. The required moment of inertia of intermediate vertical stiffeners shall be computed from $I = 0.00000028\ H^4$ where H is the clear depth of the web.

26. Riveted or welded splices in the webs of plate girders shall be designed for the full strength of the web in both shear and bending.

27. Riveted splices or welded joints of tension members shall have a strength in the net section of the splice plate equal to that of the material spliced. The rivets of the splice shall have a strength 10 per cent in excess of the member.

28. Metal shall not be less than 5/16 in. thick for classification ASTM A-7 steel, or 1/4 in. for high tensile steel, unless otherwise specified on information sheets.

29. The depth of the girder shall not be less than 1/18 of the span unless otherwise approved by the purchaser.

30. The total vertical deflection of the girder in inches for the live load plus trolley, and not including impact or dead load of girder itself, shall not exceed 0.001 inches per inch of span. Girders shall be cambered an amount equal to the dead load deflection plus one-half the live load and the trolley deflections.

31. Girders shall be proportioned by the moment of inertia of the net section, deducting the rivet holes in the tension area.

32. Full length diaphragms are required at bridge drive supports and line shaft bearing pedestals on the motor girder. Vertical stiffeners or full length diaphragms may be used interchangeably when required by 17-G-10.

33. In addition to the required full length diaphragms for box section girders, short diaphragms shall be inserted where required to transmit the trolley wheel load to the web plates and to limit the maximum stress in the trolley rail to 18,000 pounds per square inch based on formula:

$$\text{Stress} = \frac{\text{Wheel load} \times \text{Distance between supports, in inches}}{6 \times \text{Section modulus of rail}}$$

34. Top cover plate shall not be considered as giving support to the rail, in computing the rail size.

35. All diaphragms must bear against the top coverplate. The thickness of the diaphragm must be sufficient to resist the trolley wheel load in bearing, on the assumption that the wheel load is distributed over a distance equal to the width of the rail base plus twice the thickness of the coverplate.

36. If the purchaser so specifies on the information sheets, cranes shall be provided with a full length wearing plate under the trolley runway rails. This plate is to be 3/8 in. thick, at least as wide as the rail base, and welded in place to the cover plate with a minimum of 3/16 in. continuous welds.

37. Stresses for high tensile steels with yield points other than those given in the foregoing shall, in general, be in proportion. The yield point of such steels shall not be taken as more than 75 per cent of the ultimate strength.

TABLE 17-VI

Values of Stiffener Coefficient

	Values of C, for the following values of web thickness, T, in inches					
	5/16	3/8	7/16	1/2	9/16	5/8
Riveted steel — one stiffener	1.07	1.37	1.67	1.99	2.29	2.64
Riveted steel — two stiffeners	0.59	0.73	0.87	1.02	1.17	1.33
Welded steel — one stiffener	1.14	1.46	1.79	2.13	2.48	2.84
Welded steel — two stiffeners	0.65	0.80	0.95	1.11	1.27	1.44

$$\gamma_1 = C\left(\frac{H}{T}\right)^2 f_c\ (10)^{-9}$$

γ_1 = required radius of gyration of one stiffener about face of web, in inches
H = clear depth of web
T = thickness of web
f_c = maximum compression stress in clear depth of web
C = appropriate value selected from above table

For more exact values, the designer is referred to: "Theory of Elastic Stability Applied to Structural Design" by L. S. Moisseiff and F. Lienhard, Proc. ASCE, Jan., 1940. The above values were taken from this paper.

H. The design of girders at the ends shall be such that the unit shear in the web plates due to the end reaction plus that due to torsion shall not exceed the values given in the tabulation for the various classifications of steel.

I. Girders, other than notched, for 4-wheel cranes shall be rigidly attached to the end carriages. They shall be tied together by vertical end plates. The vertical end plates shall be capable of resisting the torsional moment at the end of the girder, and the rivets or welds on these plates shall be capable of developing this moment. Horizontal plates shall also be provided across the top and ends of the bridge girders. The vertical and horizontal end plates shall have a section modulus equal to that at the end of the bridge girder. Gusset plates shall be provided to assist in keeping the crane square.

J. Notched girders for 4-wheel cranes shall also be provided with horizontal and vertical end plates as above, and shall be rigidly attached to the end carriage along the vertical edge of the notch as well as the top edge. Girders with bottom cover plate in line with bottom of end carriage, shall be provided with large gusset plates to connect the bottom cover plate to the bottom of the end carriage.

K. Girders for cranes with equalizer trucks shall have rigid end ties of box construction, the inner plate of which shall be extended down the full depth of the girder before the notch. Top plate of end ties shall be made as wide as possible without interfering with the trolley travel. The section modulus of the box end tie shall be equal to the section modulus of the end of the bridge girder. The rivets or welds between the vertical plates of the box end tie and the bridge girder shall be capable of developing the torsion moments at the end of the bridge girder.

L. When lateral end fixity is used in design, the horizontal moment of inertia and horizontal section modulus of the end tie shall be at least equal to those at the end of the bridge girder. The rivets or welds in the horizontal plates of the end tie shall be capable of developing the lateral end moment.

M. Top and bottom cover plates and angles of girders shall be in one piece throughout the girder length, unless otherwise approved by the purchaser.

N. Box girders shall be so constructed as to eliminate any accumulation of water or oil inside them. If the purchaser so specifies on the information sheets, welded girders shall be provided with breathing holes to allow for the expansion or contraction of the air inside due to temperature changes. Special care shall be taken with cranes for outdoor use to eliminate crevices or openings where water may accumulate and cause corrosion.

O. Capacity of each hoist shall be shown in pounds on each side of crane in such a manner as to be easily legible from the floor.

P. An adequate number of fitted bolts for drilled and reamed holes shall be provided to accurately aline the girders with the end trucks during field erection. Connection between girders and end trucks shall be as specified on the information sheet.

Q. Squaring marks shall be provided on each girder to facilitate erection and squaring of the bridge.

18. Bridge End Carriages:

A. End carriage shall be of cast steel or structural steel welded, and they shall be made amply strong to prevent breakage under the most severe strains resulting from legitimate use of crane.

B. There shall be a heavy safety lug or strap across the bottom of each carriage near the track-wheel and one inch above the top of rail, to prevent excessive drop in case of breakage of track wheel, axle, or carriage. Wheel base shall not be less than 1/8 of the span on long span cranes. On 8-wheel cranes, the wheel base is the distance between center lines of the two outside wheels.

C. No part of carriage or track wheel gears shall project below the flange of track wheel.

D. End carriage is to be designed so as to permit easy changing of the wheels.

E. Pads shall be provided for the use of jacks or wedges when changing track wheels.

F. Guards of an approved design which will push forward or off the track any object placed across it, such as a person's foot or arm, shall be attached to each end of the carriages. Certain designs require means of supporting guards while bumpers are being removed.

G. If specified on the information sheets, safe means must be provided to get on the bridge of the crane from the crane runway.

H. If specified on the information sheets, all cranes with equalizer trucks shall be provided with steel platforms, on inside of carriages, to give access to all wheels and bearings.

19. Trolley Frames:

A. The trolley frame shall be welded rolled steel or cast steel construction or a combination of both as specified on the information sheets. The requirements for the bridge end carriages regarding safety lugs, guards, ease of changing wheels and clearances shall also apply to the trolley.

B. Where practicable, all bearing brackets shall be integral with the frames.

C. Roller bearing housing and bearings should be so designed that shaft and bearings, as well as bearing housings and glands, can be fitted up complete as a spare.

D. Drum bearings and support for upper sheaves shall be located so as to equalize the load on track wheels as nearly as possible.

E. The trolley shall be of the floored-over type with no openings except for the ropes and magnet cable. Deck plates shall be not less than 5/16 in. thick and shall be provided with toe guards around all openings or edges. The load girt is to be designed to carry the load to the side frames.

20. Foot-Walks:

A. Level steel foot-walks made either of anti-slip type floor plate with a minimum thickness of 3/16 in. or expanded metal or subway type grating (if allowed by applicable state code) shall be provided on the outside of the girders on which the bridge drive is mounted for the full length of the girder, and for double the length of the trolley on the idler girder, unless full length

walkway is specified on the information sheets. The foot-walks are to be equipped on both sides with toe angles or bent plate at least 6 in. x 3 in. x ¼ in. in size. The inside angle shall fit against the vertical stiffener angles. It is not necessary to fill in between the inside toe angle and the web of the girder unless called for by the applicable state code.

B. Foot-walks shall be of sufficient width to give at least 18 in. clear passage at all points, except between railing and bridge drive where the clearance may be reduced to not less than 15 in. The clearance between railing on bridge walk and nearest part of trolley shall not be less than 18 in.

C. The foot-walk along girders should have at least 6 ft 6 in. clearance below roof chords, unless waived by purchaser. Foot-walk floor plates shall preferably be welded to supports. If riveted, rivets shall be countersunk on top, if required by the state code or purchaser.

D. Width of trolley walks, if provided, shall not be less than 15 in.

21. Railings:

A. Railings on foot-walks shall be preferably made of structural steel; shall be of purchaser's standard construction and not less than 42 in. high, and with an intermediate member 21 in. high. Toe angles or bent plates, not less than 6 in. high, are required except on stairs.

B. Railings shall be provided on girder foot-walks, ends of bridge, landing on cab, and on stairs leading to bridge girder from landing on cab as specified.

22. Stairs and Ladders:

A. Steps or ladders shall be provided to give easy access from cab to bridge foot-walk as called for on information sheets. If other steps or ladders are required they should be listed under special features as specified on the information sheet. Location and design of steps shall be such as to eliminate blind spots during crane operation, wherever possible.

B. Stair treads shall be of material designed to prevent slipping, and shall not be less than 21 in. in width. Where stairs are not constructed with risers, a plate or wire mesh shield shall be attached to the underside, extending the entire length.

C. Where ladders are provided they shall be of steel and have rungs welded to ladder to prevent turning. The rails shall extend 42 in. above landing place at top, where possible, for safety in getting on or off the ladder. They shall start on a landing platform.

D. Where slope of stairs would exceed an angle of 50 degrees from the horizontal, ladders shall be used.

E. All foot-walks, railings, ladders, or steps shall be made so as not to interfere with the removal of any part of crane.

23. Operator's Cab:

A. The operator's cab shall be built of structural steel and fireproof material with a clear height, with equipment installed, of not less than 6 ft 6 in., and shall be made substantial and rigid by proper gusset plates and braces welded or riveted. Such bracing, however, shall not interfere with access to cab or vision of operator. Cab shall also be braced to prevent swinging, and shall be supported by members having all rivets in shear.

B. Enclosed cabs shall have a watertight plate roof which slopes to the rear and be provided with sliding or drop windows on three sides, and with sliding or hinged door. Steel plates for enclosing sides shall be not less than ⅛ in. thick. Window sash shall be equipped with clear shatterproof glass installed from the inside so that if it comes out it will fall in the cab. Windows which drop shall be protected from breakage by ⅛ in. sheet steel guard, extending to within 2 in. of the floor, and be provided with handles and stops which will prevent catching a man's hands or toes when operating the windows. Drop windows shall be counterweighted.

C. Open cabs shall have rear side enclosed with ⅛ in. steel plate. Other three sides shall be enclosed with standard railing 42 in. high, with space between floor and intermediate member enclosed with ⅛ in. steel plate. Where the top rail, if placed 42 in. above the floorline, seriously interferes with the operator's vision, it may be lowered if approved by the purchaser.

D. The floor of the cab, which shall be ¼ in. thick steel plate, is to be extended to form a landing platform which is to be provided with hand railing similar in design to that specified for foot-walks. Floor of cage is to be covered with suitable thermal and insulation material ¾ in. thick.

E. Cranes subjected to heat from below must have 3/16 in. sheet steel shield, 6 in. below bottom of floor, to insulate floor from heat.

F. If specified on the information sheets, enclosed cabs shall be provided with a combination heating and ventilating unit of size specified. Unit to be provided with switch for disconnecting the heating unit when not required.

G. Cab shall be provided with a multiple ringing steel foot gong, not less than 12 in. in diameter, or other suitable warning signal appliance, installed so as to be readily accessible from the cab and located so that parts working loose cannot fall from crane.

H. The above requirements shall be modified if cabs are located other than at the end of the bridge in order to give the operator maximum visibility in all directions at all times. These cabs shall be provided with ladders to the foot-walk and shall be only large enough to house the master controllers, manual controllers, and disconnecting devices in cab. All other control apparatus will be mounted on the foot-walks.

Mechanical Details

24. Drums:

A. Drums shall be made of rolled or cast steel or special high strength cast iron as specified on the information sheets, and shall have flanged ends of not less than 1 in. in thickness projecting 2½ in. beyond the body of the drum.

B. Drums shall have turned grooves of a depth equal to 7/16 of the diameter of the hoisting rope, and a pitch of not less than 1.2 times this diameter. Groove radius shall be 1/32 in. larger than the radius of the rope. Drums shall be so designed that not less than two complete wraps of hoisting rope will remain in the grooves when the hook is at the lowest position, and not require

overlapping of rope when hook is in the highest position.

C. The pitch diameter of the drum for 6 x 37 wire rope shall not be less than 30 times the diameter of the hoisting rope used, and the ratio for 6 x 19 rope shall not be less than 45.

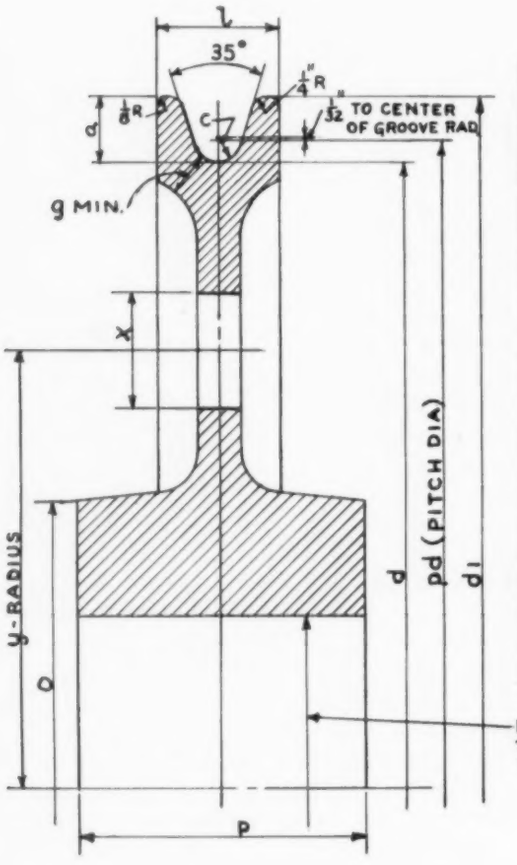
D. Drum gear shall be pressed on and keyed to either the periphery or the hub of the drum, or be bolted with body bound bolts to a flange on the drum.

25. Ropes:

A. The hoisting ropes shall be of the grade and type specified on the information sheets.

B. The standard diameters of hoisting rope shall be $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, 1, $1\frac{1}{8}$, and $1\frac{1}{4}$ in.

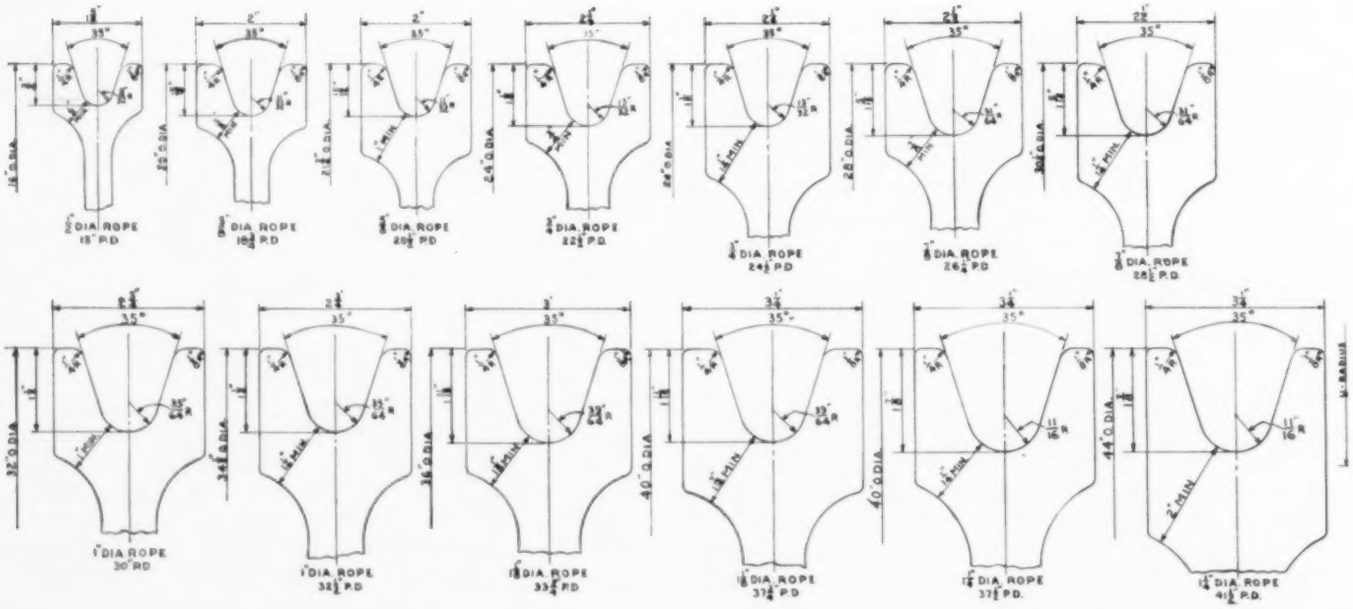
C. Where main conductors are located below the runway rail, a guard shall be provided on the crane



DIMENSION	WHEEL CLASS - A.I. & S.E.												
	S 15	S 18¾	S 20½	S 22½	S 24½	S 26¼	S 28½	S 30	S 32½	S 33¾	S 37¾	S 37½	S 41½
ROPE SIZE	½	⅝	⅝	¾	¾	⅞	⅞	1	1	1⅛	1⅛	1¼	1¼
a	¾	15/16	15/16	1⅛	1⅛	1 5/16	1 5/16	1½	1½	1 11/16	1 11/16	1⅞	1⅞
c	9/32	11/32	11/32	13/32	13/32	31/64	31/64	35/64	35/64	39/64	39/64	11/16	11/16
d	14½	18⅛	19⅞	21¾	23¾	25⅜	27⅝	29	31½	32⅝	36⅝	36¼	40¼
d1	16	20	21¾	24	26	28	30¼	32	34½	36	40	40	44
pd	15	18¾	20½	22½	24½	26¼	28½	30	32½	33¾	37¾	37½	41½
g	½	⅝	1	¾	1¼	⅞	1¼	1	1¼	1⅛	1 7/16	1¼	2
l	1⅝	2	2	2¼	2¼	2½	2½	2¾	2¾	3	3¼	3¼	3¼
o	8	9½	9½	11	11	13	13	14	14	15½	15½	15½	15½
p	4	4¾	4¾	5	5	5½	5½	5½	5½	5½	6	6	6
No. WEB HOLES	4	4	4	4	4	4	4	4	4	4	4	4	4
x	1½	1½	2	2	2	2½	2½	3	3	3	3	3	3
y	5½	7	7¼	8¼	8½	9½	10	10¾	11¼	12	12¾	12¾	13¼

TABLE 27-I

Figure 27-I


½" DIA ROPE 15" P.D
⅝" DIA ROPE 18¾" P.D
¾" DIA ROPE 20½" P.D
¾" DIA ROPE 22½" P.D
¾" DIA ROPE 24½" P.D
⅞" DIA ROPE 26¼" P.D
⅞" DIA ROPE 28½" P.D
1" DIA ROPE 30" P.D
1" DIA ROPE 32½" P.D
1" DIA ROPE 33¾" P.D
1⅛" DIA ROPE 37¾" P.D
1¼" DIA ROPE 37½" P.D.
1¼" DIA ROPE 41½" P.D.

to prevent the hoisting ropes from coming in contact with the conductors.

D. When practical, ropes shall be so reeved as to eliminate reverse bends.

26. Equalizer Bar or Sheaves:

A. Where required, either an equalizer bar or sheave will be acceptable. In either case, it shall be so designed as to be accessible from floor of trolley and made in such a manner that it can turn or swivel to aline itself with the pull on ropes. Equalizer sheaves when used shall have a pitch diameter not less than 18 times the diameter of the rope.

27. Sheaves and Hook Blocks:

A. Sheaves shall be bronze bushed or provided with anti-friction bearings as specified. In either case, proper provision to take care of thrust will be made. The sheaves shall be used in standard sizes and in accordance with the data given in Table 27-I and Figure 27-1.

B. The pitch diameter of all sheaves, except equalizer sheaves, shall be not less than 30 times the diameter of the rope used for 6 x 37 rope, and not less than 45 times the diameter for 6 x 19 rope. Sheaves shall be enclosed by guards which fit close to the flanges so as to prevent the ropes from coming out of the grooves.

C. Bottom sheave blocks shall be constructed of rolled, forged or cast steel and be entirely enclosed except for the rope openings. The hook trunnion, which shall be separated from the sheave pin, shall be supported by extending the side plates below the sheave housing. Hook shall swivel on ball or other type of anti-friction bearing constructed to exclude dirt and also shall be provided with means of lubrication.

D. Each sheave shall be lubricated by an individual grease line, the fittings to be located so that they will be protected from injury.

E. Where feasible, top sheaves shall be mounted above the trolley floor; otherwise should be accessible by means of a removable plate in the floor.

28. Track Wheels:

A. All track wheels are to be of rolled or forged open hearth steel, or of an accepted cast alloy, and treated or untreated as specified on the information sheets. Wheels shall be double flanged.

1. Straight tread wheels shall be as specified by Table 28-I.
2. Tapered tread wheels shall be as specified by Table 28-II.

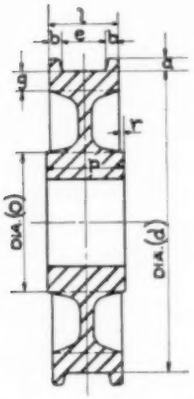
B. In the classification number given the wheels, CR indicates crane service, S or T indicate straight or tapered tread, the next number indicates the tread diameter of the center of the wheel in inches, and the last letter indicates the type of wheel of this diameter. X after the design letter indicates that the wheels are for use under existing equipment only, and are not to be used for the design of new equipment.

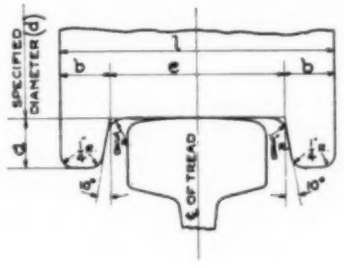
C. Wheels shall be mounted on the axles with a press fit and keys, with a press fit alone, or with keys alone as specified on the information sheets. The standard wheel sections called for in these specifications have sufficient hub wall thickness for the use of keys.

D. The maximum load on any track wheel with trolley handling the maximum working load and at the cab end of the cranes shall not exceed the values in Table 29-1.

E. In case the size of the bridge runway rail section as specified by the purchaser is the deciding factor as to whether 4 or 8 wheels are required on the crane, the purchaser should be notified before complete proposal is prepared so purchaser can give consideration to a heavier section.

F. Trolley track wheels shall have straight treads which shall be ½ in. wider than the width of the rail





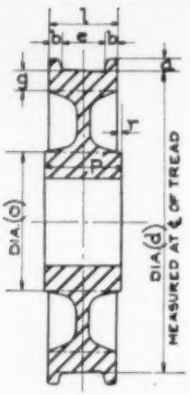
STRAIGHT TREAD WHEELS
FOR USE WITH NEW OR EXISTING EQUIPMENT

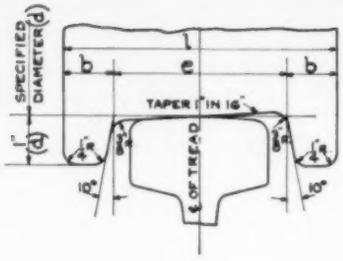
TABLE 28-I

FOR USE WITH EXISTING EQUIPMENT ONLY

WHEEL CLASS	CRS 12A	CRS 15A	CRS 15B	CRS 18A	CRS 21A	CRS 24A	CRS 24B	CRS 24C	CRS 24D	CRS 27A	CRS 27B	CRS 27C	CRS 30A	CRS 30B	CRS 30C	CRS 36A
a	3/4"	3/4"	3/4"	1"	1"	1"	1"	1"	1"	1"	1"	1"	1"	1"	1"	1"
b	13/16"	13/16"	1"	1"	1"	1"	1"	1"	1"	1"	1"	1"	1"	1"	1"	1"
d	12"	15"	15"	18"	21"	24"	24"	24"	24"	27"	27"	27"	30"	30"	30"	36"
e	2 7/8"	2 7/8"	3 1/8"	3 1/8"	3 1/8"	3 1/8"	3 1/2"	4 3/4"	4 3/4"	3 1/2"	4 3/4"	4 3/4"	3 1/2"	4 3/4"	4 3/4"	4 3/4"
g	5/8"	1"	1"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	2"	2"	2"	2"	2"	2"	2"	2"	3"
l	4 1/2"	4 1/2"	5 1/8"	5 1/8"	5 1/8"	5 1/8"	5 1/2"	6 3/4"	6 3/4"	5 1/2"	6 3/4"	6 3/4"	5 1/2"	6 3/4"	6 3/4"	6 3/4"
o	5 3/4"	7 1/2"	7 1/2"	7 1/2"	10"	8"	11"	11"	12 1/2"	11"	11"	14"	12"	12"	15"	15"
p	5"	5 1/2"	5 1/2"	6"	5 3/4"	6"	6"	7 1/2"	7 1/2"	6 1/2"	7 1/2"	7 1/2"	7"	7 1/2"	7 1/2"	7 1/2"
r	1/4"	1/2"	3/8"	7/16"	5/16"	7/16"	1/4"	3/8"	3/8"	1/2"	3/8"	3/8"	1/4"	3/8"	3/8"	3/8"

WHEEL CLASS	CRS 12AX	CRS 12BX	CRS 18AX	CRS 20AX
a	13/16"	13/16"	1"	1"
b	13/16"	13/16"	1"	1"
d	12"	12"	18"	20"
e	2 3/8"	2 7/8"	4 3/4"	3 1/8"
g	5/8"	5/8"	1 1/2"	1 1/2"
l	4"	4 1/2"	6 3/4"	5 1/8"
o	5 3/4"	6 1/2"	9"	7 1/2"
p	5"	6"	6 3/4"	5 7/8"
r	1/2"	3/4"	0"	3/8"





TAPERED TREAD WHEELS
FOR USE WITH NEW OR EXISTING EQUIPMENT

TABLE 28-II

FOR USE WITH EXISTING EQUIPMENT ONLY

WHEEL CLASS	CRT 24A	CRT 24B	CRT 24C	CRT 24D	CRT 24E	CRT 27A	CRT 27B	CRT 27C	CRT 30A	CRT 30B	CRT 30C	CRT 36A
a	1"	1"	1"	1"	1"	1"	1"	1"	1"	1"	1"	1"
b	7/8"	7/8"	7/8"	7/8"	7/8"	7/8"	7/8"	7/8"	7/8"	7/8"	7/8"	1"
d	24"	24"	24"	24"	24"	27"	27"	27"	30"	30"	30"	36"
e	4"	4"	4 1/2"	5 1/2"	5 1/2"	4 1/2"	5 1/2"	5 1/2"	4 1/2"	5 1/2"	5 1/2"	5 1/2"
g	1 1/2"	1 1/2"	1 1/2"	2"	2"	2"	2"	2"	2"	2"	2"	3"
l	5 3/4"	5 3/4"	6 1/4"	7 1/4"	7 1/4"	6 1/4"	7 1/4"	7 1/4"	6 1/4"	7 1/4"	7 1/4"	7 1/2"
o	9"	11"	11"	11"	12 1/2"	11"	11"	14"	12"	12"	15"	15"
p	6"	6"	6 3/4"	7 1/2"	7 1/2"	6 3/4"	7 1/2"	7 1/2"	6 3/4"	7 1/2"	7 1/2"	7 3/4"
r	1/8"	1/8"	1/4"	1/8"	1/8"	1/4"	1/8"	1/8"	1/4"	1/8"	1/8"	1/8"

WHEEL CLASS	CRT 18AX	CRT 18BX	CRT 20AX	CRT 21AX	CRT 27AX	CRT 30AX
a	1"	1"	1"	1"	1"	1"
b	7/8"	7/8"	7/8"	7/8"	1"	1"
d	18"	18"	20"	21"	27"	30"
e	4 3/4"	5 1/2"	4"	4"	6"	6"
g	1 1/2"	1 1/2"	1 1/2"	1 1/2"	2"	2"
l	6 1/2"	7 1/4"	5 3/4"	5 3/4"	8"	8"
o	11"	11"	7 1/2"	10"	13 1/2"	13 1/2"
p	6 1/2"	8"	6"	6"	7"	7"
r	0"	3/8"	1/8"	1/8"	-1/2"	-1/2"

head. Whenever standard wheel dimensions do not permit, this clearance may be reduced to 3/8 in. Wheels will have standard dimensions given in Table 28-I.

29. Rails:

A. Unless otherwise specified on information sheet, all rails shall be first quality and of following sections: ASCE 60 lb per yard; crane rail section 104-105 lb per yard; crane rail section 135-136 lb per yard; and crane rail section 171-175 lb per yard.

B. Joints on trolley travel rails shall be made by means of standard joint bars. The ends of rails shall be milled and laid with no openings between the ends. Provision shall be made to prevent creeping of rails on girders by means of stops riveted or welded to cover plate.

C. For box girders, rails shall be fastened in place by suitable clamps, held either by direct welding to the cover plate or by studs welded to the cover plate, or with studs fitted into nuts welded to underside of cover plate before assembly of girder, as specified on the information sheets. Rails shall be fastened in place by steel clamps he ld by through bolts for single web girders unless otherwise specified on the information sheets. Fastenings are to be spaced on not more than 36 in. centers.

D. Rails for trolley travel shall not be less than ASCE 60 lb section. Rails for bridge travel shall not be less than crane rail section 104-105 lb.

E. Wheel loads on rails shall not exceed those given in Table 29-I.

30. Bumpers:

A. The crane shall be provided with substantial

TABLE 29-I

Diameter of wheel, in.	Rail section			
	ASCE 60 lb	Crane rail section 104-105 lb	Crane rail section 135-136 lb	Crane rail section 171-175 lb
12	28,000*	.....	.....	.....
15	35,000*	.....	.....	.....
18	42,000	50,000*	.....	.....
21	49,000	59,000	.....	.....
24	56,000	67,000	89,000*	.....
27	.....	73,000	95,000	128,000*
30	.....	76,000	102,000	135,000
36	.....	79,000	109,000	142,000

*These values will most likely be determined by the stresses in the axle shafts.

bumpers of spring or draft gear type, capable of stopping the crane (not including the lifted load) when traveling in either direction at 20 per cent of the rated full load speed, and at an average rate of deceleration not to exceed 3 ft per sec per sec. In addition, bumper springs shall have sufficient energy absorbing capacity to stop the crane when traveling at a speed of at least 40 per cent of full load rated speed. Bumpers should be so mounted that there is no direct shear on bolts.

B. Bridge bumpers shall have a contact surface not less than 5 in. in diameter, be located on the rail center line and be of such length that no part of either crane will be damaged when bumpers of two cranes come together and both are fully compressed. Bumpers shall be rigidly bolted in place, and if bumpers are so located as to require removal when changing trackwheels, means shall be provided on the crane itself, either by hinges or otherwise, for handling the bumper while changing track wheels.

C. Height of bumpers above top of rail shall be as specified on information sheets.

D. Trolley shall be provided with spring type bumpers capable of stopping the trolley (not including the lifted load) when traveling in either direction at $\frac{1}{3}$ of the full load rated speed and at an average rate of deceleration not to exceed 4.7 ft per sec per sec. Where two trolleys are operated on the same bridge, they shall be equipped with spring bumpers on their adjacent ends.

E. The design of all bumpers shall be such that in case of breakage, no part can fall from crane.

31. Bridge Drives:

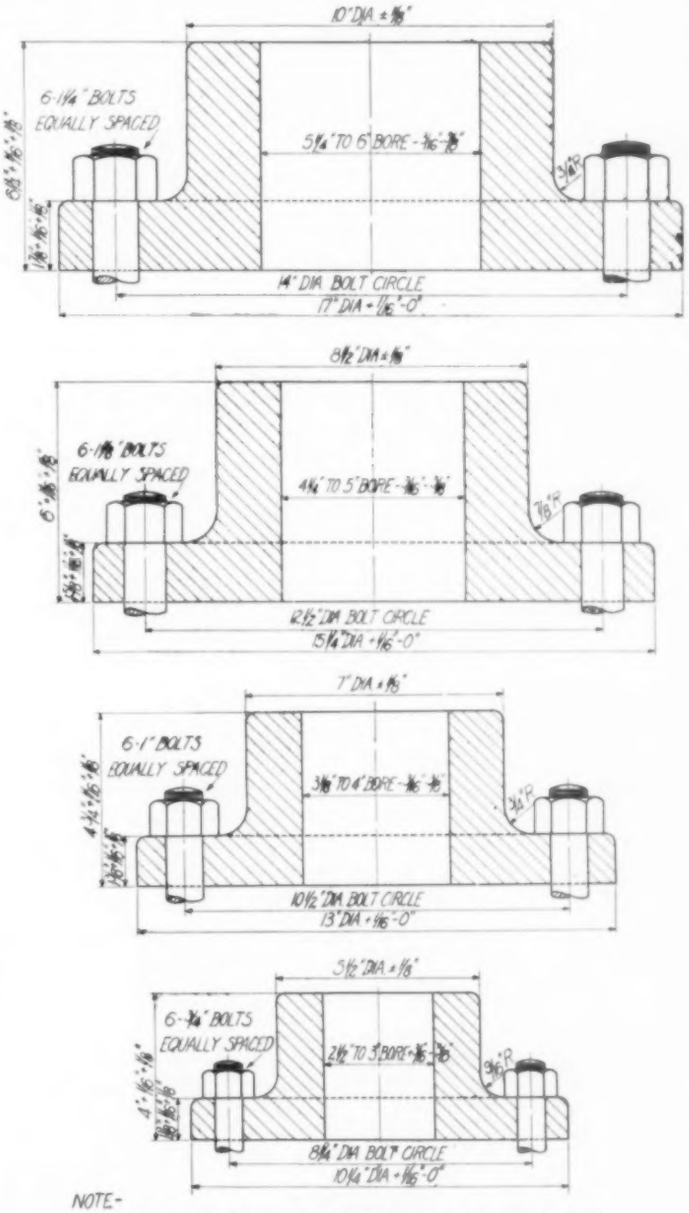
A. Bridge drive shall consist of one of the following arrangements, as specified on information sheets.

1. Back axle motor located at center of bridge. Track wheels driven through gears pressed and keyed on their axles and pinion mounted on end section of line shaft. End section of line shaft shall be connected to line shaft by means of half flexible couplings unless otherwise specified. All other couplings shall be solid type.
2. Plain motor connected by means of flexible couplings to self-contained gear reduction located at center of bridge. Motor to be mounted above the line shaft in order to keep it as close to girder as possible. Balance of arrangement same as (A-1).
3. Plain motor located at center of bridge connected directly to line shaft. Self-contained gear reduction sets, located near each end of bridge, connected to wheel axle shafts by means of short shafts with half flexible couplings at each end of these shafts. All other couplings shall be solid type, unless high speed shafts of gear reduction have no end play due to type of bearings used, in which case they shall be connected to line shaft by means of half flexible couplings.
4. Plain motor located at center of bridge connected directly to line shaft. Gear reduction sets built in or attached to end trucks, and driving track wheels through gears pressed and keyed on their axles. Line shaft shall be connected to gear reduction sets by means of half flexible couplings. All other couplings shall be solid.
5. Plain motor located at center of bridge and connected by means of flexible coupling to self-contained gear reduction unit located at center of bridge, which shall be connected by sections of line shaft having solid coupling to self contained gear reductions located near each end of crane, and these connected to bridge track wheels by means of floating shafts with half flexible couplings.
6. Dual bridge drives, plain motor located at each end of bridge, connected with torque shaft in accordance with A-3.

B. The length of any section of line shaft shall not be more than that specified on the information sheets. End sections are to be made as short as practicable, and interchangeable. Line shaft sections for double drive bridge should be duplicates.

C. Line shaft couplings, other than the flexible type, are to be made from rolled or forged steel. Couplings shall be located close to bearings and provided with

Figure 31-1


10" DIA ± 1/16"
6-1 1/4" BOLTS EQUALLY SPACED
5 1/16" TO 6" BORE - 3/16" - 1/8"
3/16" R
14" DIA BOLT CIRCLE
17" DIA ± 1/16" - 0"
8 1/2" DIA ± 1/16"
6-1" BOLTS EQUALLY SPACED
4 1/16" TO 5" BORE - 3/16" - 1/8"
1/8" R
12 1/2" DIA BOLT CIRCLE
15 1/4" DIA ± 1/16" - 0"
7" DIA ± 1/16"
6-1" BOLTS EQUALLY SPACED
3 1/16" TO 4" BORE - 3/16" - 1/8"
3/16" R
10 1/2" DIA BOLT CIRCLE
13" DIA ± 1/16" - 0"
5 1/2" DIA ± 1/16"
6-3/4" BOLTS EQUALLY SPACED
2 1/16" TO 3" BORE - 3/16" - 1/8"
3/16" R
8 1/4" DIA BOLT CIRCLE
10 1/4" DIA ± 1/16" - 0"

NOTE-
COUPLINGS TO BE FURNISHED ROUGH TURNED ALL OVER TO SIZES AND TOLERANCES SHOWN

substantial removable guards at least 12 in. wide. Where half flexible couplings are used, the couplings shall be located close to the bearing on the end truck, and the adjacent line shaft bearing shall not be closer than 4 ft 6 in. Four standard sizes of couplings will be used as follows:

1. For shafting 2½ to 3 in. diameter.
2. For shafting 3⅛ to 4 in. diameter.
3. For shafting 4¼ to 5 in. diameter.
4. For shafting 5¼ to 6 in. diameter.

D. Couplings will be standardized to correspond with the four shown in Figure 31-1.

E. The load will be carried through the couplings by one of the following methods, as specified on the information sheets.

1. Six body-bound bolts.
2. By the use of face keys between the two halves of the coupling, plus plain bolts. Standard keys will be ⅝ in. x 1¼ in., ¾ in. x 1½ in., ⅞ in. x 2 in. and 1 in. x 2¼ in. Two such keys will be used, each extending to within 1/16 in. of the bore and placed on the center line of two opposite bolt holes, or with one key extending full length, and shaft cut back so key can be pushed through.

F. Type of bearings will be as specified on information sheets. Line shaft bearings will not be spaced more than 10 ft on centers.

G. Supports for motor and reduction gear sets shall be welded structural steel rigidly attached to the crane girder by means of attachments extending the full depth of the girder, and so designed as to produce no lateral bending of the web plates.

H. Bolts for fastening bearing brackets, motors and gear reduction sets shall be easily accessible from top side of foot-walk.

I. Angular deflection of the lineshaft at torque corresponding to 1⅓ times full load motor torque, shall not exceed 0.08 degrees per foot of shaft length. In computing deflections when gear transmitting torque to shaft is located at the span center, ⅔ the torque is taken by each half of the shaft.

J. Bridge speed, gear ratio and bridge drive motor size shall be calculated according to methods set forth in Section 43 of these specifications.

32. Shafting:

A. Shafting shall be increased in diameter in ⅛ in. increments, to twice the key-seat depth for a distance equal to the length of the hub fit for pinions, gears, track wheels and drums when tapered keys are used. When parallel faced sunk keys are used, the shaft shall be increased in diameter by 10 per cent to the nearest ⅛ in. increment. A generous fillet or long taper is to be provided at each end of the swell. Shafting need not be increased in size for couplings.

B. The diameter of plain shafting shall be in even ¼ in. sizes.

C. Plain shafting, 6 in. or under in diameter, not having swells or increases, shall be cold or hot rolled or drawn; all above that diameter shall be forged and machined to size.

D. All shafting above 6 in. in diameter, if not hardened, shall be either annealed or normalized and tempered.

E. Sheave pins, pivot pins for equalizer trucks, and axle shafts which are provided with sleeve bearings are to be either case hardened, ground and polished, or ground, polished and nitrided. Surface hardness will be 80 or 90 Shore, depth of case will be 3/16 in. if case hardened.

33. Press Fits and Keys:

A. Keys shall be provided for all connections subject to torsion, except as otherwise specified on the information sheets, and except idler track wheels or drums which are not driven through the shaft. Key sizes shall be in accordance with those listed in ASA B17.1-1943. Tapered keys shall bear on sides, top and bottom, (parallel faced keys shall bear on sides only). All gears, pinions, wheels and couplings shall be pressed or shrunk onto shafts in addition to being keyed as specified on the information sheets. All press fits shall be made in accordance with those prescribed in the American Standards Association B4a-1925 (Tolerances, Allowances, and Gages for Metal Fits). Class 7 fits will be used with cast iron. Class 8 fits will be used with steel.

34. Bearings:

A. Bearings shall be as specified on the information sheets.

B. Where anti-friction type bearings are specified, the size selected shall be such as to give a minimum life expectancy of 10 years (5000-40,000 hr) under service conditions for which the crane is intended. Required hours service per year will be that given for the motion concerned (bridge, trolley or hoist) unless otherwise specified. Table 34-I, through Table 34-IX, gives recommended bearing applications for track wheels. Drawings showing size and type of bearing, details of application, mounting and method of application, shall be submitted by contractor to the bearings manufacturer for approval.

C. Anti-friction line shaft bearings shall have inner races, and preferably be of self-alining type. Method of securing inner race to shaft is to be approved by purchaser.

D. Anti-friction bearings shall be fitted with grease or oil seals of a type approved by purchaser.

E. Housings for anti-friction bearings shall be split, or so designed to permit easy removal of the shaft.

F. With track wheel bearings of anti-friction type, one bearing on each track wheel axle shall be of fixed double thrust type; the other bearing shall be arranged to allow for expansion or float of the axle.

G. Sleeve bearings (except those on wheel axles or sealed sleeve type) shall be split horizontally and finished with steel caps finished male and female and held by through bolts with locked nuts. They shall be lined with split bushings of hard bronze, or its equal, with flanges on both ends, and held from turning by a heavy lug cast on the top half. Bottom shall be designed to permit its removal and renewal without removing shaft.

H. Where sleeve bearings are applied to track wheel axles, the bearing pressure shall not exceed 750 psi of projected area. Bearings are to be of such design as to exclude dirt, prevent leakage of oil or grease, eliminate the necessity for frequent oiling or replacement of oil, and meet with approval of purchaser.

I. All bearing caps shall be accurately bored in place with the housings.

TABLE 34-I BEARINGS FOR BRIDGE AND TROLLEY TRACK WHEEL AXLES

HYATT BEARINGS DIVISION

FIXED DOUBLE THRUST TYPE BEARINGS

Maximum load per box, lb		Uniform bearing bore, in.	Class 4 40,000 hour B10 life			Class 3 30,000 hour B10 life			Class 2 20,000 hour B10 life			Class 1 10,000 hour B10 life			Class 0 5,000 hour B10 life		
			1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm
1,000	Uniform	0.9843	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z
	Variable		A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z	A-25205-Z
3,000	Uniform	1.5748	A-25208-Z	A-25208-Z	A-25208-Z	A-25208-Z	A-25208-Z	A-25208-Z	A-25208-Z	A-25208-Z	A-25208-Z	A-25208-Z	A-25208-Z	A-25208-Z	A-25208-Z	A-25208-Z	A-25208-Z
	Variable		A-25207-Z (1.3780)	A-25207-Z (1.3780)	A-25208-Z (1.5748)	A-25206-Z (1.1811)	A-25207-Z (1.3780)	A-25208-Z (1.5748)	A-25206-Z (1.1811)	A-25207-Z (1.3780)	A-25207-Z (1.3780)	A-25206-Z (1.1811)	A-25206-Z (1.1811)	A-25206-Z (1.1811)	A-25206-Z (1.1811)	A-25206-Z (1.1811)	A-25206-Z (1.1811)
5,000	Uniform	2.1654	A-25211-Z	A-25211-Z	A-25211-Z	A-25211-Z	A-25211-Z	A-25211-Z	A-25211-Z	A-25211-Z	A-25211-Z	A-25211-Z	A-25211-Z	A-25211-Z	A-25211-Z	A-25211-Z	A-25211-Z
	Variable		A-25209-Z (1.7717)	A-25210-Z (1.9685)	A-25211-Z (2.1654)	A-25208-Z (1.5748)	A-25210-Z (1.9685)	A-25211-Z (2.1654)	A-25208-Z (1.5748)	A-25209-Z (1.7717)	A-25210-Z (1.9685)	A-25208-Z (1.5748)	A-25208-Z (1.5748)	A-25208-Z (1.5748)	A-25208-Z (1.5748)	A-25208-Z (1.5748)	A-25208-Z (1.5748)
7,000	Uniform	2.5591	A-25213-Z	A-25213-Z	A-25213-Z	A-25213-Z	A-25213-Z	A-25213-Z	A-25213-Z	A-25213-Z	A-25213-Z	A-25213-Z	A-25213-Z	A-25213-Z	A-25213-Z	A-25213-Z	A-25213-Z
	Variable		A-25211-Z (2.1654)	A-25212-Z (2.3622)	A-25213-Z (2.5591)	A-25210-Z (1.9685)	A-25212-Z (2.3622)	A-25213-Z (2.5591)	A-25209-Z (1.7717)	A-25211-Z (2.1654)	A-25212-Z (2.3622)	A-25209-Z (1.7717)	A-25209-Z (1.7717)	A-25211-Z (2.1654)	A-25209-Z (1.7717)	A-25209-Z (1.7717)	A-25209-Z (1.7717)
9,000	Uniform	2.9528	A-25215-Z	A-25215-Z		A-25215-Z	A-25215-Z	A-25215-Z	A-25215-Z	A-25215-Z	A-25215-Z	A-25215-Z	A-25215-Z	A-25215-Z	A-25215-Z	A-25215-Z	A-25215-Z
	Variable		A-25213-Z (2.5591)	A-25214-Z (2.7559)	A-25216-Z (3.1496)	A-25212-Z (2.3622)	A-25213-Z (2.5591)	A-25215-Z (2.9528)	A-25211-Z (2.1654)	A-25213-Z (2.5591)	A-25214-Z (2.7559)	A-25210-Z (1.9685)	A-25212-Z (2.3622)	A-25213-Z (2.5591)	A-25210-Z (1.9685)	A-25210-Z (1.9685)	A-25211-Z (2.1654)
10,000	Uniform	3.1496	A-25216-Z	A-25216-Z		A-25216-Z	A-25216-Z	A-25216-Z	A-25216-Z	A-25216-Z	A-25216-Z	A-25216-Z	A-25216-Z	A-25216-Z	A-25216-Z	A-25216-Z	A-25216-Z
	Variable		A-25213-Z (2.5591)	A-25215-Z (2.9528)	A-25217-Z (3.3465)	A-25213-Z (2.5591)	A-25214-Z (2.7559)	A-25216-Z (3.1496)	A-25212-Z (2.3622)	A-25213-Z (2.5591)	A-25215-Z (2.9528)	A-25211-Z (2.1654)	A-25212-Z (2.3622)	A-25213-Z (2.5591)	A-25211-Z (2.1654)	A-25211-Z (2.1654)	A-25212-Z (2.3622)
12,000	Uniform	3.3465	A-25217-Z	A-25217-Z		A-25217-Z	A-25217-Z	A-25217-Z	A-25217-Z	A-25217-Z	A-25217-Z	A-25217-Z	A-25217-Z	A-25217-Z	A-25217-Z	A-25217-Z	A-25217-Z
	Variable		A-25215-Z (2.9528)	A-25217-Z (3.3465)	A-25218-Z (3.5433)	A-25214-Z (2.7559)	A-25216-Z (3.1496)	A-25217-Z (3.3465)	A-25213-Z (2.5591)	A-25215-Z (2.9528)	A-25216-Z (3.1496)	A-25212-Z (2.3622)	A-25213-Z (2.5591)	A-25214-Z (2.7559)	A-25212-Z (2.3622)	A-25212-Z (2.3622)	A-25213-Z (2.5591)
15,000	Uniform	3.7402	A-25219-Z	A-25219-Z		A-25219-Z	A-25219-Z	A-25219-Z	A-25219-Z	A-25219-Z	A-25219-Z	A-25219-Z	A-25219-Z	A-25219-Z	A-25219-Z	A-25219-Z	A-25219-Z
	Variable		A-25217-Z (3.3465)	A-25219-Z (3.7402)	A-25220-Z (3.9370)	A-25216-Z (3.1496)	A-25218-Z (3.5433)	A-25219-Z (3.7402)	A-25215-Z (2.9528)	A-25217-Z (3.3465)	A-25218-Z (3.5433)	A-25214-Z (2.7559)	A-25215-Z (2.9528)	A-25216-Z (3.1496)	A-25214-Z (2.7559)	A-25214-Z (2.7559)	A-25214-Z (2.7559)
18,000	Uniform	3.9370	A-25220-Z	A-25220-Z		A-25220-Z	A-25220-Z		A-25220-Z	A-25220-Z	A-25220-Z	A-25220-Z	A-25220-Z	A-25220-Z	A-25220-Z	A-25220-Z	A-25220-Z
	Variable		A-25218-Z (3.5433)	A-25220-Z (3.9370)	A-25222-Z (4.3307)	A-25218-Z (3.5433)	A-25219-Z (3.7402)	A-25221-Z (4.1339)	A-25217-Z (3.3465)	A-25218-Z (3.5433)	A-25220-Z (3.9370)	A-25215-Z (2.9528)	A-25217-Z (3.3465)	A-25218-Z (3.5433)	A-25215-Z (2.9528)	A-25215-Z (2.9528)	A-25216-Z (3.1496)
20,000	Uniform	4.1339	A-25221-Z	A-25221-Z		A-25221-Z	A-25221-Z		A-25221-Z	A-25221-Z	A-25221-Z	A-25221-Z	A-25221-Z	A-25221-Z	A-25221-Z	A-25221-Z	A-25221-Z
	Variable		A-25219-Z (3.7402)	A-25221-Z (4.1339)	A-25224-Z (4.7244)	A-25218-Z (3.5433)	A-25220-Z (3.9370)	A-25222-Z (4.3307)	A-25217-Z (3.3465)	A-25219-Z (3.7402)	A-25221-Z (4.1339)	A-25216-Z (3.1496)	A-25217-Z (3.3465)	A-25219-Z (3.7402)	A-25216-Z (3.1496)	A-25216-Z (3.1496)	A-25217-Z (3.3465)
24,000	Uniform	4.3307	A-25222-Z			A-25222-Z	A-25222-Z		A-25222-Z	A-25222-Z	A-25222-Z	A-25222-Z	A-25222-Z	A-25222-Z	A-25222-Z	A-25222-Z	A-25222-Z
	Variable		A-25221-Z (4.1339)	A-25224-Z (4.7244)	A-25226-Z (5.1181)	A-25220-Z (3.9370)	A-25222-Z (4.3307)	A-25224-Z (4.7244)	A-25219-Z (3.7402)	A-25221-Z (4.1339)	A-25222-Z (4.3307)	A-25217-Z (3.3465)	A-25219-Z (3.7402)	A-25220-Z (3.9370)	A-25217-Z (3.3465)	A-25217-Z (3.3465)	A-25218-Z (3.5433)
30,000	Uniform	4.7244	A-25224-Z			A-25224-Z			A-25224-Z	A-25224-Z		A-25224-Z	A-25224-Z	A-25224-Z	A-25224-Z	A-25224-Z	A-25224-Z
	Variable		A-25224-Z (4.7244)	A-25226-Z (5.1181)	A-25230-Z (5.9055)	A-25222-Z (4.3307)	A-25226-Z (5.1181)	A-25226-Z (5.1181)	A-25221-Z (4.1339)	A-25224-Z (4.7244)	A-25226-Z (5.1181)	A-25219-Z (3.7402)	A-25221-Z (4.1339)	A-25222-Z (4.3307)	A-25219-Z (3.7402)	A-25219-Z (3.7402)	A-25220-Z (3.9370)
40,000	Uniform	5.5118	A-25226-Z			A-25226-Z			A-25226-Z	A-25226-Z		A-25226-Z	A-25226-Z	A-25226-Z	A-25226-Z	A-25226-Z	A-25226-Z
	Variable		A-25226-Z (5.1181)	A-25232-Z (6.2992)	A-25234-Z (6.6929)	A-25226-Z (5.1181)	A-25230-Z (5.9055)	A-25232-Z (6.2992)	A-25226-Z (5.1181)	A-25226-Z (5.1181)	A-25230-Z (5.9055)	A-25222-Z (4.3307)	A-25226-Z (5.1181)	A-25226-Z (5.1181)	A-25222-Z (4.3307)	A-25222-Z (4.3307)	A-25224-Z (4.7244)
50,000	Uniform	6.2992	A-25232-Z			A-25232-Z			A-25232-Z	A-25232-Z		A-25232-Z	A-25232-Z	A-25232-Z	A-25232-Z	A-25232-Z	A-25232-Z
	Variable		A-25232-Z (6.2992)	A-25236-Z (7.0866)	A-25240-Z (7.8740)	A-25230-Z (5.9055)	A-25234-Z (6.6929)	A-25238-Z (7.4803)	A-25228-Z (5.5118)	A-25232-Z (6.2992)	A-25234-Z (6.6929)	A-25226-Z (5.1181)	A-25228-Z (5.5118)	A-25230-Z (5.9055)	A-25226-Z (5.1181)	A-25226-Z (5.1181)	A-25226-Z (5.1181)
60,000	Uniform	7.4803	A-25238-Z			A-25238-Z	A-25238-Z		A-25238-Z	A-25238-Z	A-25238-Z	A-25238-Z	A-25238-Z	A-25238-Z	A-25238-Z	A-25238-Z	A-25238-Z
	Variable		A-25234-Z (6.6929)	A-25240-Z (7.8740)	A-25244-Z (8.6614)	A-25232-Z (6.2992)	A-25238-Z (7.4803)	A-25244-Z (8.6614)	A-25230-Z (5.9055)	A-25234-Z (6.6929)	A-25238-Z (7.4803)	A-25228-Z (5.5118)	A-25230-Z (5.9055)	A-25234-Z (6.6929)	A-25228-Z (5.5118)	A-25228-Z (5.5118)	A-25230-Z (5.9055)
70,000	Uniform	7.8740	A-25240-Z			A-25240-Z			A-25240-Z	A-25240-Z		A-25240-Z	A-25240-Z	A-25240-Z	A-25240-Z	A-25240-Z	A-25240-Z
	Variable		A-25238-Z (7.4803)	A-25244-Z (8.6614)	A-25248-Z (9.4488)	A-25236-Z (7.0866)	A-25240-Z (7.8740)	A-25244-Z (8.6614)	A-25234-Z (6.6929)	A-25238-Z (7.4803)	A-25244-Z (8.6614)	A-25230-Z (5.9055)	A-25234-Z (6.6929)	A-25238-Z (7.4803)	A-25230-Z (5.9055)	A-25230-Z (5.9055)	A-25232-Z (6.2992)
80,000	Uniform	8.6614	A-25244-Z			A-25244-Z	A-25244-Z		A-25244-Z	A-25244-Z		A-25244-Z	A-25244-Z	A-25244-Z	A-25244-Z	A-25244-Z	A-25244-Z
	Variable		A-25244-Z (8.6614)	A-25248-Z (9.4488)		A-25240-Z (7.8740)	A-25244-Z (8.6614)	A-25248-Z (9.4488)	A-25238-Z (7.4803)	A-25244-Z (8.6614)	A-25248-Z (9.4488)	A-25232-Z (6.2992)	A-25238-Z (7.4803)	A-25240-Z (7.8740)	A-25232-Z (6.2992)	A-25232-Z (6.2992)	A-25234-Z (6.6929)
90,000	Uniform	9.4488	A-25248-Z			A-25248-Z	A-25248-Z		A-25248-Z	A-25248-Z	A-25248-Z	A-25248-Z	A-25248-Z	A-25248-Z	A-25248-Z	A-25248-Z	A-25248-Z
	Variable		A-25244-Z (8.6614)			A-25244-Z (8.6614)	A-25248-Z (9.4488)		A-25240-Z (7.8740)	A-25244-Z (8.6614)	A-25248-Z (9.4488)	A-25234-Z (6.6929)	A-25240-Z (7.8740)	A-25244-Z (8.6614)	A-25234-Z (6.6929)	A-25234-Z (6.6929)	A-25238-Z (7.4803)
100,000	Uniform	9.4488	A-25248-Z			A-25248-Z	A-25248-Z		A-25248-Z	A-25248-Z		A-25248-Z	A-25248-Z	A-25248-Z	A-25248-Z	A-25248-Z	A-25248-Z
	Variable		A-25248-Z (9.4488)			A-25244-Z (8.6614)	A-25248-Z (9.4488)		A-25244-Z (8.6614)	A-25248-Z (9.4488)		A-25238-Z (7.4803)	A-25244-Z (8.6614)	A-25248-Z (9.4488)	A-25238-Z (7.4803)	A-25238-Z (7.4803)	A-25240-Z (7.8740)

TABLE 34-II BEARINGS FOR BRIDGE AND TROLLEY TRACK WHEEL AXLES

HYATT BEARINGS DIVISION

EXPANSION OR FLOATING BEARINGS

Maximum load per box, lb		Uniform bearing bore, in.	Class 4 40,000 hour B10 life			Class 3 30,000 hour B10 life			Class 2 20,000 hour B10 life			Class 1 10,000 hour B10 life			Class 0 5,000 hour B10 life		
			1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm
1,000	Uniform	0.9843	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS
	Variable		A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS	A-5205-TS
3,000	Uniform	1.5748	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS
	Variable		A-5206-TS (1.1811)	A-5207-TS (1.3780)	A-5208-TS (1.5748)	A-5206-TS (1.1811)	A-5207-TS (1.3780)	A-5207-TS (1.3780)	A-5206-TS (1.1811)	A-5206-TS (1.1811)	A-5207-TS (1.3780)	A-5206-TS (1.1811)	F-5206-TS (1.1811)	A-5206-TS (1.1811)	A-5206-TS (1.1811)	A-5206-TS (1.1811)	A-5206-TS (1.1811)
5,000	Uniform	2.1654	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS
	Variable		A-5208-TS (1.5748)	A-5210-TS (1.9685)	A-5211-TS (2.1654)	A-5208-TS (1.5748)	A-5209-TS (1.7717)	A-5210-TS (1.9685)	A-5208-TS (1.5748)	A-5208-TS (1.5748)	A-5209-TS (1.7717)	A-5208-TS (1.5748)	A-5208-TS (1.5748)	A-5208-TS (1.5748)	A-5208-TS (1.5748)	A-5208-TS (1.5748)	A-5208-TS (1.5748)
7,000	Uniform	2.5591	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS
	Variable		A-5211-TS (2.1654)	A-5212-TS (2.3622)	A-5213-TS (2.5591)	A-5210-TS (1.9685)	A-5211-TS (2.1654)	A-5212-TS (2.3622)	A-5209-TS (1.7717)	A-5211-TS (2.1654)	A-5212-TS (2.3622)	A-5209-TS (1.7717)	A-5209-TS (1.7717)	A-5210-TS (1.9685)	A-5209-TS (1.7717)	A-5209-TS (1.7717)	A-5209-TS (1.7717)
9,000	Uniform	2.9528	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS
	Variable		A-5212-TS (2.3622)	A-5214-TS (2.7559)	A-5216-TS (3.1496)	A-5212-TS (2.3622)	A-5213-TS (2.5591)	A-5214-TS (2.7559)	A-5211-TS (2.1654)	A-5212-TS (2.3622)	A-5214-TS (2.7559)	A-5210-TS (1.9685)	A-5211-TS (2.1654)	A-5212-TS (2.3622)	A-5210-TS (1.9685)	A-5210-TS (1.9685)	A-5210-TS (1.9685)
10,000	Uniform	3.1496	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS
	Variable		A-5213-TS (2.5591)	A-5214-TS (2.7559)	A-5216-TS (3.1496)	A-5212-TS (2.3622)	A-5214-TS (2.7559)	A-5216-TS (3.1496)	A-5212-TS (2.3622)	A-5213-TS (2.5591)	A-5214-TS (2.7559)	A-5211-TS (2.1654)	A-5212-TS (2.3622)	A-5212-TS (2.3622)	A-5211-TS (2.1654)	A-5211-TS (2.1654)	A-5211-TS (2.1654)
12,000	Uniform	3.3465	A-5217-TS	A-5217-TS	A-5217-TS	A-5217-TS	A-5217-TS	A-5217-TS	A-5217-TS	A-5217-TS	A-5217-TS	A-5217-TS	A-5217-TS	A-5217-TS	A-5217-TS	A-5217-TS	A-5217-TS
	Variable		A-5214-TS (2.7559)	A-5216-TS (3.1496)	A-5217-TS (3.3465)	A-5214-TS (2.7559)	A-5216-TS (3.1496)	A-5217-TS (3.3465)	A-5213-TS (2.5591)	A-5214-TS (2.7559)	A-5216-TS (3.1496)	A-5212-TS (2.3622)	A-5212-TS (2.3622)	A-5214-TS (2.7559)	A-5212-TS (2.3622)	A-5212-TS (2.3622)	A-5212-TS (2.3622)
15,000	Uniform	3.7402	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS
	Variable		A-5216-TS (3.1496)	A-5218-TS (3.5433)	A-5219-TS (3.7402)	A-5216-TS (3.1496)	A-5217-TS (3.3465)	A-5218-TS (3.5433)	A-5214-TS (2.7559)	A-5216-TS (3.1496)	A-5217-TS (3.3465)	A-5214-TS (2.7559)	A-5214-TS (2.7559)	A-5216-TS (3.1496)	A-5214-TS (2.7559)	A-5214-TS (2.7559)	A-5214-TS (2.7559)
18,000	Uniform	3.9370	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS
	Variable		A-5218-TS (3.5433)	A-5219-TS (3.7402)	A-5220-TS (3.9370)	A-5217-TS (3.3465)	A-5218-TS (3.5433)	A-5220-TS (3.9370)	A-5216-TS (3.1496)	A-5218-TS (3.5433)	A-5219-TS (3.7402)	A-5215-TS (2.9528)	A-5216-TS (3.1496)	A-5217-TS (3.3465)	A-5215-TS (2.9528)	A-5215-TS (2.9528)	A-5216-TS (3.1498)
20,000	Uniform	4.1339	A-5221-TS	A-5221-TS	A-5321-TS	A-5221-TS	A-5221-TS	A-5221-TS	A-5221-TS	A-5221-TS	A-5221-TS	A-5221-TS	A-5221-TS	A-5221-TS	A-5221-TS	A-5221-TS	A-5221-TS
	Variable		A-5218-TS (3.5433)	A-5220-TS (3.9370)	A-5222-TS (4.3307)	A-5218-TS (3.5433)	A-5219-TS (3.7402)	A-5221-TS (4.1339)	A-5217-TS (3.3465)	A-5218-TS (3.5433)	A-5219-TS (3.7402)	A-5216-TS (3.1496)	A-5217-TS (3.3465)	A-5218-TS (3.5433)	A-5216-TS (3.1496)	A-5216-TS (3.1496)	A-5216-TS (3.1496)
24,000	Uniform	4.3307	A-5222-TS	A-5222-TS	A-5322-TS	A-5222-TS	A-5222-TS	A-5322-TS	A-5222-TS	A-5222-TS	A-5222-TS	A-5222-TS	A-5222-TS	A-5222-TS	A-5222-TS	A-5222-TS	A-5222-TS
	Variable		A-5219-TS (3.7402)	A-5222-TS (4.3307)	A-5226-TS (5.1181)	A-5219-TS (3.7402)	A-5221-TS (4.1339)	A-5224-TS (4.7244)	A-5218-TS (3.5433)	A-5220-TS (3.9370)	A-5221-TS (4.1339)	A-5217-TS (3.3465)	A-5218-TS (3.5433)	A-5219-TS (3.7402)	A-5217-TS (3.3465)	A-5217-TS (3.3465)	A-5218-TS (3.5433)
30,000	Uniform	4.7244	A-5224-TS	A-5324-TS	A-5324-TS	A-5224-TS	A-5324-TS	A-5324-TS	A-5224-TS	A-5224-TS	A-5324-TS	A-5224-TS	A-5224-TS	A-5224-TS	A-5224-TS	A-5224-TS	A-5224-TS
	Variable		A-5222-TS (4.3307)	A-5226-TS (5.1181)	A-5228-TS (5.5118)	A-5221-TS (4.1339)	A-5226-TS (5.1181)	A-5228-TS (5.5118)	A-5220-TS (3.9370)	A-5222-TS (4.3307)	A-5226-TS (5.1181)	A-5219-TS (3.7402)	A-5220-TS (3.9370)	A-5221-TS (4.1339)	A-5219-TS (3.7402)	A-5219-TS (3.7402)	A-5219-TS (3.7402)
40,000	Uniform	5.5118	A-5228-TS	A-5328-TS	A-5328-TS	A-5228-TS	A-5228-TS	A-5328-TS	A-5228-TS	A-5228-TS	A-5328-TS	A-5228-TS	A-5228-TS	A-5228-TS	A-5228-TS	A-5228-TS	A-5228-TS
	Variable		A-5228-TS (5.5118)	A-5230-TS (5.9055)	A-5234-TS (6.6929)	A-5226-TS (5.1181)	A-5228-TS (5.5118)	A-5232-TS (6.2992)	A-5224-TS (4.7244)	A-5228-TS (5.5118)	A-5230-TS (5.9055)	A-5222-TS (4.3307)	A-5224-TS (4.7244)	A-5226-TS (5.1181)	A-5222-TS (4.3307)	A-5222-TS (4.3307)	A-5222-TS (4.3307)
50,000	Uniform	6.2992	A-5232-TS	A-5332-TS	A-5332-TS	A-5232-TS	A-5232-TS	A-5332-TS	A-5232-TS	A-5232-TS	A-5332-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS
	Variable		A-5230-TS (5.9055)	A-5234-TS (6.6929)	A-5238-TS (7.4803)	A-5228-TS (5.5118)	A-5232-TS (6.2992)	A-5234-TS (6.6929)	A-5228-TS (5.5118)	A-5230-TS (5.9055)	A-5234-TS (6.6929)	A-5226-TS (5.1181)	A-5228-TS (5.5118)	A-5230-TS (5.9055)	A-5226-TS (5.1181)	A-5226-TS (5.1181)	A-5226-TS (5.1181)
60,000	Uniform	7.4803	A-5238-TS	A-5238-TS	A-5338-TS	A-5238-TS	A-5238-TS	A-5338-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS
	Variable		A-5234-TS (6.6929)	A-5238-TS (7.4803)	A-5244-TS (8.6614)	A-5232-TS (6.2992)	A-5234-TS (6.6929)	A-5240-TS (7.8740)	A-5230-TS (5.9055)	A-5234-TS (6.6929)	A-5238-TS (7.4803)	A-5228-TS (5.5118)	A-5230-TS (5.9055)	A-5232-TS (6.2992)	A-5228-TS (5.5118)	A-5228-TS (5.5118)	A-5228-TS (5.5118)
70,000	Uniform	7.8740	A-5240-TS	A-5340-TS	A-5340-TS	A-5240-TS	A-5240-TS	A-5340-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS
	Variable		A-5236-TS (7.0866)	A-5244-TS (8.6614)	A-5244-TS (8.6614)	A-5234-TS (6.6929)	A-5240-TS (7.8740)	A-5244-TS (8.6614)	A-5232-TS (6.2992)	A-5236-TS (7.0866)	A-5240-TS (7.8740)	A-5230-TS (5.9055)	A-5232-TS (6.2992)	A-5234-TS (6.6929)	A-5230-TS (5.9055)	A-5230-TS (5.9055)	A-5232-TS (6.2992)
80,000	Uniform	8.6614	A-5244-TS	A-5244-TS	A-5344-WB	A-5244-TS	A-5244-TS	A-5344-WB	A-5244-TS	A-5244-TS	A-5244-TS	A-5244-TS	A-5244-TS	A-5244-TS	A-5244-TS	A-5244-TS	A-5244-TS
	Variable		A-5240-TS (7.8740)	A-5244-TS (8.6614)	A-5248-TS (9.4488)	A-5238-TS (7.4803)	A-5244-TS (8.6614)	A-5248-TS (9.4488)	A-5234-TS (6.6929)	A-5240-TS (7.8740)	A-5244-TS (8.6614)	A-5232-TS (6.2992)	A-5234-TS (6.6929)	A-5238-TS (7.4803)	A-5232-TS (6.2992)	A-5232-TS (6.2992)	A-5234-TS (6.6929)
90,000	Uniform	9.4488	A-5248-TS	A-5248-TS	A-5348-WB	A-5248-TS	A-5248-TS	A-5348-WB	A-5248-TS	A-5248-TS	A-5248-TS	A-5248-TS	A-5248-TS	A-5248-TS	A-5248-TS	A-5248-TS	A-5248-TS
	Variable		A-5244-TS (8.6614)	A-5248-TS (9.4488)	A-5344-WB (8.6614)	A-5240-TS (7.8740)	A-5244-TS (8.6614)	A-5340-TS (7.8740)	A-5238-TS (7.4803)	A-5244-TS (8.6614)	A-5244-TS (8.6614)	A-5234-TS (6.6929)	A-5238-TS (7.4803)	A-5240-TS (7.8740)	A-5234-TS (6.6929)	A-5234-TS (6.6929)	A-5234-TS (6.6929)
100,000	Uniform	9.4488	A-5248-TS	A-5348-WB	A-5348-WB	A-5248-TS	A-5248-TS	A-5348-WB	A-5248-TS	A-5248-TS	A-5248-TS	A-5248-TS	A-5248-TS	A-5248-TS	A-5248-TS	A-5248-TS	A-5248-TS
	Variable		A-5244-TS (8.6614)	A-5344-WB (8.6614)	A-5344-WB (8.6614)	A-5244-TS (8.6614)	A-5248-TS (9.4488)	A-5344-WB (8.6614)	A-5240-TS (7.8740)	A-5244-TS (8.6614)	A-5248-TS (9.4488)	A-5238-TS (7.4803)	A-5240-TS (7.8740)	A-5244-TS (8.6614)	A-5238-TS (7.4803)	A-5238-TS (7.4803)	A-5238-TS (7.4803)

TABLE 34-III BEARINGS FOR BRIDGE AND TROLLEY TRACK WHEEL AXLES*

NORMA-HOFFMANN BEARINGS CORP.

Box load		Bearing bore	Class 4 40,000 hour B10 life			Class 3 30,000 hour B10 life			Class 2 20,000 hour B10 life			Class 1 10,000 hour B10 life			Class 0 5,000 hour B10 life		
			1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm
1,000	Uniform	0.9843	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L
	Variable		R-117-L (0.6693)	R-125-L (0.9843)	R-125-L (0.9843)	R-117-L (0.6693)	R-120-L (0.7874)	R-125-L (0.9843)	R-117-L (0.6693)	R-117-L (0.6693)	R-125-L (0.9843)	R-115 (0.5906)	R-117-L (0.6693)	R-117-L (0.6693)	R-110 (0.3937)	R-115 (0.5906)	R-117-L (0.6693)
3,000	Uniform	1.5748	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P
	Variable		RY-330-P (1.1811)	RY-335-P (1.3780)	RY-340-P (1.5748)	RY-330-P (1.1811)	RY-330-P (1.1811)	RY-335-P (1.3780)	RY-325-P (0.9843)	RY-330-P (1.1811)	RY-330-P (1.1811)	RY-325-P (0.9843)	RY-325-P (0.9843)	RY-330-P (1.1811)	RY-325-P (0.9843)	RY-325-P (0.9843)	RY-325-P (0.9843)
5,000	Uniform	1.9685	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P
	Variable		RY-340-P (1.5748)	RY-350-P (1.9685)	RY-350-P (1.9685)	RY-340-P (1.5748)	RY-345-P (1.7717)	RY-350-P (1.9685)	RY-335-P (1.3780)	RY-340-P (1.5748)	RY-345-P (1.7717)	RY-330-P (1.1811)	RY-335-P (1.3780)	RY-340-P (1.5748)	RY-325-P (0.9843)	RY-330-P (1.1811)	RY-335-P (1.3780)
7,000	Uniform	2.5591	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P
	Variable		RY-350-P (1.9685)	RY-360-P (2.3622)	RY-365-P (2.5591)	RY-350-P (1.9685)	RY-355-P (2.1654)	RY-360-P (2.3622)	RY-345-P (1.7717)	RY-350-P (1.9685)	RY-360-P (2.3622)	RY-340-P (1.5748)	RY-345-P (1.7717)	RY-350-P (1.9685)	RY-330-P (1.1811)	RY-340-P (1.5748)	RY-345-P (1.7717)
9,000	Uniform	2.9528	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P
	Variable		RY-360-P (2.3622)	RY-365-P (2.5591)	RY-375-P (2.9528)	RY-360-P (2.3622)	RY-365-P (2.5591)	RY-370-P (2.7559)	RY-350-P (1.9685)	RY-360-P (2.3622)	RY-365-P (2.5591)	RY-345-P (1.7717)	RY-350-P (1.9685)	RY-360-P (2.3622)	RY-340-P (1.5748)	RY-345-P (1.7717)	RY-350-P (1.9685)
10,000	Uniform	3.1496	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P
	Variable		RY-365-P (2.5591)	RY-370-P (2.7559)	RY-380-P (3.1496)	RY-360-P (2.3622)	RY-365-P (2.5591)	RY-375-P (2.9528)	RY-355-P (2.1654)	RY-360-P (2.3622)	RY-365-P (2.5591)	RY-345-P (1.7717)	RY-355-P (2.1654)	RY-360-P (2.3622)	RY-340-P (1.5748)	RY-350-P (1.9685)	RY-350-P (1.9685)
12,000	Uniform	3.3465	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P
	Variable		RY-365-P (2.5591)	RY-380-P (3.1496)	RY-385-P (3.3465)	RY-365-P (2.5591)	RY-375-P (2.9528)	RY-380-P (3.1496)	RY-360-P (2.3622)	RY-365-P (2.5591)	RY-375-P (2.9528)	RY-350-P (1.9685)	RY-360-P (2.3622)	RY-365-P (2.5591)	RY-345-P (1.7717)	RY-350-P (1.9685)	RY-360-P (2.3622)
15,000	Uniform	3.7402	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P
	Variable		RY-380-P (3.1496)	RY-390-P (3.5433)	RY-395-P (3.7402)	RY-375-P (2.9528)	RY-385-P (3.3465)	RY-390-P (3.5433)	RY-365-P (2.5591)	RY-380-P (3.1496)	RY-385-P (3.3465)	RY-360-P (2.3622)	RY-365-P (2.5591)	RY-375-P (2.9528)	RY-350-P (1.9685)	RY-360-P (2.3622)	RY-365-P (2.5591)
18,000	Uniform	3.9370	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P
	Variable		RY-385-P (3.3465)	RY-395-P (3.7402)	RY-400-P (3.9370)	RY-380-P (3.1496)	RY-390-P (3.5433)	RY-395-P (3.7402)	RY-375-P (2.9528)	RY-385-P (3.3465)	RY-390-P (3.5433)	RY-365-P (2.5591)	RY-375-P (2.9528)	RY-385-P (3.3465)	RY-360-P (2.3622)	RY-365-P (2.5591)	RY-375-P (2.9528)
20,000	Uniform	4.1339	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P
	Variable		RY-390-P (3.5433)	RY-400-P (3.9370)	RY-405-P (4.1339)	RY-385-P (3.3465)	RY-395-P (3.7402)	RY-400-P (3.9370)	RY-380-P (3.1496)	RY-390-P (3.5433)	RY-395-P (3.7402)	RY-370-P (2.7559)	RY-380-P (3.1496)	RY-385-P (3.3465)	RY-365-P (2.5591)	RY-370-P (2.7559)	RY-380-P (3.1496)
24,000	Uniform	4.3307	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P
	Variable		RY-395-P (3.7402)	RY-405-P (4.1339)	RY-410-P (4.3307)	RY-395-P (3.7402)	RY-400-P (3.9370)	RY-405-P (4.1339)	RY-385-P (3.3465)	RY-395-P (3.7402)	RY-405-P (4.1339)	RY-380-P (3.1496)	RY-385-P (3.3465)	RY-395-P (3.7402)	RY-365-P (2.5591)	RY-380-P (3.1496)	RY-385-P (3.3465)
30,000	Uniform	5.1181	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P
	Variable		RY-405-P (4.1339)	RY-420-P (4.7244)	RY-430-P (5.1181)	RY-400-P (3.9370)	RY-410-P (4.3307)	RY-420-P (4.7244)	RY-395-P (3.7402)	RY-405-P (4.1339)	RY-410-P (4.3307)	RY-385-P (3.3465)	RY-395-P (3.7402)	RY-405-P (4.1339)	RY-380-P (3.1496)	RY-385-P (3.3465)	RY-395-P (3.7402)
40,000	Uniform	5.9055	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P
	Variable		RY-420-P (4.7244)	RY-440-P (5.5118)	RY-450-P (5.9055)	RY-410-P (4.3307)	RY-430-P (5.1181)	RY-450-P (5.9055)	RY-405-P (4.1339)	RY-420-P (4.7244)	RY-430-P (5.1181)	RY-395-P (3.7402)	RY-405-P (4.1339)	RY-410-P (4.3307)	RY-390-P (3.5433)	RY-400-P (3.9370)	RY-405-P (4.1339)
50,000	Uniform																
	Variable		RY-440-P (5.5118)			RY-430-P (5.1181)	RY-450-P (5.9055)		RY-420-P (4.7244)	RY-440-P (5.5118)	RY-450-P (5.9055)	RY-405-P (4.1339)	RY-420-P (4.7244)	RY-430-P (5.1181)	RY-400-P (3.9370)	RY-405-P (4.1339)	RY-420-P (4.7244)
60,000	Uniform																
	Variable		RY-450-P (5.9055)			RY-450-P (5.9055)			RY-430-P (5.1181)	RY-450-P (5.9055)		RY-420-P (4.7244)	RY-430-P (5.1181)	RY-450-P (5.9055)	RY-405-P (4.1339)	RY-420-P (4.7244)	RY-430-P (5.1181)
70,000	Uniform																
	Variable								RY-430-P (5.9055)			RY-430-P (5.1181)	RY-450-P (5.9055)		RY-410-P (4.3307)	RY-430-P (5.1181)	RY-440-P (5.5118)
80,000	Uniform																
	Variable											RY-440-P (5.5118)			RY-420-P (4.7244)	RY-430-P (5.1181)	RY-450-P (5.9055)
90,000	Uniform																
	Variable											RY-450-P (5.9055)			RY-430-P (5.1181)	RY-450-P (5.9055)	
100,000	Uniform																
	Variable														RY-430-P (5.1181)		

*NOTE—The above roller bearings are medium series except those shown for the 1000 lb box load which are light series. For details of other light series bearings substituted for medium series see Table 34-IV.

TABLE 34-IV BEARINGS FOR BRIDGE AND TROLLEY TRACK WHEEL AXLES*

NORMA-HOFFMANN BEARINGS CORP.

Box load		Bearing bore	Class 4 40,000 hour B10 life			Class 3 30,000 hour B10 life			Class 2 20,000 hour B10 life			Class 1 10,000 hour B10 life			Class 0 5,000 hour B10 life		
			1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm
1,000	Uniform	0.9843	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L	R-125-L
	Variable		R-117-L (0.6693)	R-125-L (0.9843)	R-125-L (0.9843)	R-117-L (0.6693)	R-120-L (0.7874)	R-125-L (0.9843)	R-117-L (0.6693)	R-117-L (0.6693)	R-125-L (0.9843)	R-115 (0.3906)	R-117-L (0.6693)	R-117-L (0.6693)	R-110 (0.3937)	R-115 (0.5906)	R-117-L (0.6693)
3,000	Uniform	1.5748	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P	RY-340-P
	Variable		R-140-L (1.5748)			R-140-L (1.5748)			R-135-L (1.3780)	R-140-L (1.5748)		R-130-L (1.1811)	R-140-L (1.5748)	R-140-L (1.5748)	R-125-L (0.9843)	R-130-L (1.1811)	R-135-L (1.3780)
5,000	Uniform	1.9685	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P	RY-350-P
	Variable											R-140-L (1.5748)			R-140-L (1.5748)	R-140-L (1.5748)	
7,000	Uniform	2.5591	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P	RY-365-P
	Variable		R-165-L (2.5591)			R-165-L (2.5591)			R-165-L (2.5591)	R-165-L (2.5591)		R-160-L (2.3622)	R-165-L (2.5591)	R-165-L (2.5591)	R-150-L (1.9685)	R-160-L (2.3622)	R-165-L (2.5591)
9,000	Uniform	2.9528	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P	RY-375-P
	Variable								R-170-L (2.7559)			R-165-L (2.5591)	R-170-L (2.7559)		R-160-L (2.3622)	R-165-L (2.5591)	R-165-L (2.5591)
10,000	Uniform	3.1496	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P	RY-380-P
	Variable								R-180-L (3.1496)			R-165-L (2.5591)	R-180-L (3.1496)		R-160-L (2.3622)	R-165-L (2.5591)	R-180-L (3.1496)
12,000	Uniform	3.3465	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P	RY-385-P
	Variable											R-180-L (3.1496)			R-165-L (2.5591)	R-180-L (3.1496)	R-185-L (3.3465)
15,000	Uniform	3.7402	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P	RY-395-P
	Variable								R-195-L (3.7402)			R-190-L (3.5433)	R-195-L (3.7402)		R-175-L (2.9528)	R-190-L (3.5433)	R-195-L (3.7402)
18,000	Uniform	3.9370	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P	RY-400-P
	Variable											R-195-L (3.7402)			R-190-L (3.5433)	R-195-L (3.7402)	R-200-L (3.9370)
20,000	Uniform	4.1339	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P	RY-405-P
	Variable								R-205-L (4.1339)			R-195-L (3.7402)			R-190-L (3.5433)	R-195-L (3.7402)	R-205-L (4.1339)
24,000	Uniform	4.3307	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P	RY-410-P
	Variable											R-205-L (4.1339)			R-195-L (3.7402)	R-205-L (4.1339)	R-210-L (4.3307)
30,000	Uniform	5.1181	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P	RY-430-P
	Variable											R-220-L (4.7244)			R-205-L (4.1339)	R-220-L (4.7244)	R-230-L (5.1181)
40,000	Uniform	5.9055	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P	RY-450-P
	Variable											R-240-L (5.5118)			R-220-L (4.7244)	R-240-L (5.5118)	
50,000	Uniform																
	Variable														R-240-L (5.5118)		
60,000	Uniform																
	Variable																
70,000	Uniform																
	Variable																
80,000	Uniform																
	Variable																
90,000	Uniform																
	Variable																
100,000	Uniform																
	Variable																

*NOTE — The above sizes of light series roller bearings shown under variable bores may be substituted for the medium series bearings shown on Table 34-III, having approximately the same load capacity. The minimum sizes required for the applied load are shown. Larger sizes of course may be used if a uniform bore size is desired.

TABLE 34-V BEARINGS FOR BRIDGE AND TROLLEY TRACK WHEEL AXLES

ROLLWAY BEARING CO., INC.

Load per box, lb		Bore, inches	Class 4 40,000 hour B10 life			Class 3 30,000 hour B10 life			Class 2 20,000 hour B10 life			Class 1 10,000 hour B10 life			Class 0 5,000 hour B10 life		
			1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm
1,000	Uniform	1.5748	BE-5208	BE-5208	BE-5208	BE-5208	BE-5208	BE-5208	BE-5208	BE-5208	BE-5208	BE-5208	BE-5208	BE-5208	BE-5208	BE-5208	BE-5208
	Variable		BE-5205 (.9843)	BE-5205 (.9843)	BE-5205 (.9843)	BE-5205 (.9843)	BE-5205 (.9843)	BE-5205 (.9843)	BE-5205 (.9843)	BE-5205 (.9843)	BE-5205 (.9843)	BE-5205 (.9843)	BE-5205 (.9843)	BE-5205 (.9843)	BE-5205 (.9843)	BE-5205 (.9843)	BE-5205 (.9843)
3,000	Uniform	1.7717	BE-5209	BE-5209	BE-5209	BE-5209	BE-5209	BE-5209	BE-5209	BE-5209	BE-5209	BE-5209	BE-5209	BE-5209	BE-5209	BE-5209	BE-5209
	Variable		BE-5206 (1.1811)	BE-5207 (1.3780)	BE-5208 (1.5748)	BE-5206 (1.1811)	BE-5207 (1.3780)	BE-5207 (1.3780)	BE-5206 (1.1811)	BE-5206 (1.1811)	BE-5207 (1.3780)	BE-5206 (1.1811)	BE-5206 (1.1811)	BE-5206 (1.1811)	BE-5205 (.9843)	BE-5206 (1.1811)	BE-5206 (1.1811)
5,000	Uniform	2.1654	BE-5211	BE-5211	BE-5211	BE-5211	BE-5211	BE-5211	BE-5211	BE-5211	BE-5211	BE-5211	BE-5211	BE-5211	BE-5211	BE-5211	BE-5211
	Variable		BE-5208 (1.5748)			BE-5208 (1.5748)	BE-5209 (1.7717)		BE-5207 (1.3780)	BE-5208 (1.5748)	BE-5210 (1.9685)	BE-5206 (1.1811)	BE-5207 (1.3780)	BE-5208 (1.5748)	BE-5206 (1.1811)	BE-5206 (1.1811)	BE-5207 (1.3780)
7,000	Uniform	2.5591	BE-5213	BE-5213	BE-5213	BE-5213	BE-5213	BE-5213	BE-5213	BE-5213	BE-5213	BE-5213	BE-5213	BE-5213	BE-5213	BE-5213	BE-5213
	Variable		BE-5211 (2.1654)	BE-5212 (2.3622)	BE-5213	BE-5211 (2.1654)	BE-5212 (2.3622)	BE-5212 (2.3622)	BE-5209 (1.7717)	BE-5211 (2.1654)	BE-5212 (2.3622)	BE-5208 (1.5748)	BE-5209 (1.7717)	BE-5211 (2.1654)	BE-5207 (1.3780)	BE-5208 (1.5748)	BE-5208 (1.5748)
9,000	Uniform	2.9528	BE-5215	BE-5215	CS-5215	BE-5215	BE-5215	CS-5215	BE-5215	BE-5215	BE-5215	BE-5215	BE-5215	BE-5215	BE-5215	BE-5215	BE-5215
	Variable		BE-5212 (2.3622)	BE-5215	CS-5214 (2.7559)	BE-5212 (2.3622)	BE-5213 (2.5591)	BE-5213 (2.5591)	BE-5211 (2.1654)	BE-5212 (2.3622)	BE-5214 (2.7559)	BE-5209 (1.7717)	BE-5211 (2.1654)	BE-5212 (2.3622)	BE-5208 (1.5748)	BE-5209 (1.7717)	BE-5211 (2.1654)
10,000	Uniform	3.1496	BE-5216	BE-5216	CS-5216	BE-5216	BE-5216	BE-5216	BE-5216	BE-5216	BE-5216	BE-5216	BE-5216	BE-5216	BE-5216	BE-5216	BE-5216
	Variable		BE-5213 (2.5591)		CS-5215 (2.9528)	BE-5212 (2.3622)	BE-5215 (2.9528)	BE-5216	BE-5212 (2.3622)	BE-5213 (2.5591)		BE-5211 (2.1654)	BE-5212 (2.3622)	BE-5212 (2.3622)	BE-5208 (1.5748)	BE-5211 (2.1654)	BE-5211 (2.1654)
12,000	Uniform	3.5433	BE-5218	BE-5218	BE-5218	BE-5218	BE-5218	BE-5218	BE-5218	BE-5218	BE-5218	BE-5218	BE-5218	BE-5218	BE-5218	BE-5218	BE-5218
	Variable		BE-5216 (3.1496)	BE-5217 (3.3465)	BE-5218	BE-5214 (2.7559)	BE-5216 (3.1496)	BE-5217 (3.3465)	BE-5212 (2.3622)	BE-5216 (3.1496)	BE-5216 (3.1496)	BE-5211 (2.1654)	BE-5212 (2.3622)	BE-5215 (2.9528)	BE-5210 (1.9685)	BE-5211 (2.1654)	BE-5212 (2.3622)
15,000	Uniform	3.7402	BE-5219	BE-5219	CS-5219	BE-5219	BE-5219	BE-5219	BE-5219	BE-5219	BE-5219	BE-5219	BE-5219	BE-5219	BE-5219	BE-5219	BE-5219
	Variable		BE-5217 (3.3465)	BE-5218 (3.5433)	CS-5218 (3.5433)	BE-5216 (3.1496)	BE-5218 (3.5433)		BE-5216 (3.1496)	BE-5217 (3.3465)	BE-5218 (3.5433)	BE-5212 (2.3622)	BE-5216 (3.1496)	BE-5216 (3.1496)	BE-5211 (2.1654)	BE-5212 (2.3622)	BE-5215 (2.9528)
18,000	Uniform	3.9370	BE-5220	BE-5220	CS-5220	BE-5220	BE-5220	BE-5220	BE-5220	BE-5220	BE-5220	BE-5220	BE-5220	BE-5220	BE-5220	BE-5220	BE-5220
	Variable		BE-5218 (3.5433)	BE-5220	CS-5219 (3.7402)	BE-5217 (3.3465)	BE-5219 (3.7402)	BE-5220	BE-5216 (3.1496)	BE-5218 (3.5433)	BE-5219 (3.7402)	BE-5215 (2.9528)	BE-5217 (3.3465)	BE-5218 (3.5433)	BE-5212 (2.3622)	BE-5215 (2.9528)	BE-5216 (3.1496)
20,000	Uniform	3.9370	BE-5220	CS-5220	CS-5220	BE-5220	BE-5220	CS-5220	BE-5220	BE-5220	BE-5220	BE-5220	BE-5220	BE-5220	BE-5220	BE-5220	BE-5220
	Variable		BE-5218 (3.5433)	CS-5219 (3.7402)	CS-5220	BE-5218 (3.5433)	BE-5220	CS-5219 (3.7402)	BE-5217 (3.3465)	BE-5218 (3.5433)	BE-5220	BE-5216 (3.1496)	BE-5217 (3.3465)	BE-5218 (3.5433)	BE-5213 (2.5591)	BE-5216 (3.1496)	BE-5217 (3.3465)
24,000	Uniform	4.3307	BE-5222	BE-5222	CS-5222	BE-5222	BE-5222	CS-5222	BE-5222	BE-5222	BE-5222	BE-5222	BE-5222	BE-5222	BE-5222	BE-5222	BE-5222
	Variable		BE-5220 (3.9370)	BE-5222	CS-5221 (4.1339)	BE-5219 (3.7402)	BE-5222	CS-5221 (4.1339)	BE-5218 (3.5433)	BE-5220 (3.9370)	BE-5222	BE-5217 (3.3465)	BE-5218 (3.5433)	BE-5220 (3.9370)	BE-5216 (3.1496)	BE-5217 (3.3465)	BE-5218 (3.5433)
30,000	Uniform	4.7244	BE-5224	CS-5224	CS-5224	BE-5224	BE-5224	CS-5224	BE-5224	BE-5224	BE-5224	BE-5224	BE-5224	BE-5224	BE-5224	BE-5224	BE-5224
	Variable		BE-5222 (4.3307)	CS-5222 (4.3307)	CS-5224	BE-5222 (4.3307)	BE-5224	CS-5222 (4.3307)	BE-5220 (3.9370)	BE-5222 (4.3307)	BE-5224	BE-5218 (3.5433)	BE-5220 (3.9370)	BE-5222 (4.3307)	BE-5217 (3.3465)	BE-5218 (3.5433)	BE-5218 (3.5433)
40,000	Uniform	5.5118	BE-5228	CS-5228	CS-5228	BE-5228	CS-5228	CS-5228	BE-5228	BE-5228	CS-5228	BE-5228	BE-5228	BE-5228	BE-5228	BE-5228	BE-5228
	Variable		BE-5226 (5.1181)	CS-5226 (5.1181)	CS-5228	BE-5226 (5.1181)	CS-5224 (4.7244)	CS-5226 (5.1181)	BE-5224 (4.7244)	BE-5226 (5.1181)	CS-5226 (5.1181)	BE-5221 (4.1339)	BE-5224 (4.7244)	BE-5226 (5.1181)	BE-5218 (3.5433)	BE-5221 (4.1339)	BE-5222 (4.3307)
50,000	Uniform	6.2992	CS-5132	CS-5232	CS-5232	CS-5132	CS-5232	CS-5232	CS-5132	CS-5132	CS-5232	CS-5132	CS-5132	CS-5132	CS-5132	CS-5132	CS-5132
	Variable		CS-5224 (4.7244)	CS-5134 (6.6929)	CS-5230 (5.9055)	CS-5130 (5.9055)	CS-5228 (5.5118)	CS-5230 (5.9055)	CS-5128 (5.5118) BE-5226 (5.1181)	CS-5224 (4.7244)	CS-5228 (5.5118)	CS-5220 (3.9370) BE-5224 (4.7244)	CS-5224 (4.7244) BE-5226 (5.1181)	CS-5319 (3.7402)	CS-5219 (3.7402) BE-5221 (4.1339)	CS-5220 (3.9370) BE-5224 (4.7244)	CS-5222 (4.3307) BE-5226 (5.1181)
60,000	Uniform	7.4803	CS-5138	CS-5138	CS-5238	CS-5138	CS-5138	CS-5238	CS-5138	CS-5138	CS-5138	CS-5138	CS-5138	CS-5138	CS-5138	CS-5138	CS-5138
	Variable		CS-5134 (6.6929)	CS-5230 (5.9055)	CS-5326 (5.1181)	CS-5132 (6.2992)	CS-5136 (7.0866)	CS-5324 (4.7244)	CS-5130 (5.9055)	CS-5134 (6.6929)	CS-5136 (7.0866)	CS-5317 (3.3465) BE-5226 (5.1181)	CS-5319 (3.7402)	CS-5320 (3.9370)	CS-5220 (3.9370) BE-5222 (4.3307)	CS-5317 (3.3465) BE-5226 (5.1181)	CS-5319 (3.7402)
70,000	Uniform	7.8740	CS-5140	CS-5240	CS-5240	CS-5140	CS-5140	CS-5240	CS-5140	CS-5140	CS-5140	CS-5140	CS-5140	CS-5140	CS-5140	CS-5140	CS-5140
	Variable		CS-5136 (7.0866)	CS-5326 (5.1181)	CS-5328 (5.5118)	CS-5228 (5.5118)	CS-5138 (7.4803)	CS-5234 (6.6929)	CS-5320 (3.9370)	CS-5136 (7.0866)	CS-5326 (5.1181)	CS-5128 (5.5118)	CS-5320 (3.9370)	CS-5228 (5.5118)	CS-5221 (4.1339) BE-5224 (4.7244)	CS-5138 (7.4803)	CS-5132 (6.2992)
80,000	Uniform	8.6614	CS-5144	CS-5144	CS-5244	CS-5144	CS-5144	CS-5144	CS-5144	CS-5144	CS-5144	CS-5144	CS-5144	CS-5144	CS-5144	CS-5144	CS-5144
	Variable		CS-5138 (7.4803)	CS-5328 (5.5118)	CS-5330 (5.9055)	CS-5136 (7.0866)	CS-5140 (7.8740)	CS-5142 (8.2677)	CS-5228 (5.5118)	CS-5138 (7.4803)	CS-5234 (6.6929)	CS-5224 (4.7244)	CS-5228 (5.5118)	CS-5230 (5.9055)	CS-5221 (4.1339) BE-5226 (5.1181)	CS-5224 (4.7244)	CS-5134 (6.6929)
90,000	Uniform	9.4488	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148
	Variable		CS-5326 (5.1181)	CS-5236 (7.0866)	CS-5240 (7.8740)	CS-5324 (4.7244)	CS-5328 (5.5118)	CS-5330 (5.9055)	CS-5136 (7.0866)	CS-5326 (5.1181)	CS-5142 (8.2677)	CS-5320 (3.9370)	CS-5136 (7.0866)	CS-5326 (5.1181)	CS-5318 (3.5433)	CS-5320 (3.9370)	CS-5136 (7.0866)
100,000	Uniform	9.4488	CS-5148	CS-5148	CS-5248	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148
	Variable		CS-5328 (5.5118)	CS-5238 (7.4803)	CS-5242 (8.2677)	CS-5140 (7.8740)	CS-5236 (7.0866)	CS-5240 (7.8740)	CS-5138 (7.4803)	CS-5328 (5.5118)	CS-5146 (9.0551)	CS-5134 (6.6929)	CS-5138 (7.4803)	CS-5234 (6.6929)	CS-5132 (6.2992)	CS-5134 (6.6929)	CS-5136 (7.0866)

TABLE 34-VI — BEARINGS FOR BRIDGE AND TROLLEY TRACK WHEEL AXLES

SKF INDUSTRIES, INC.

Load per box, lb		Bore, inches	Class 4 40,000 hour B10 life			Class 3 30,000 hour B10 life			Class 2 20,000 hour B10 life			Class 1 10,000 hour B10 life			Class 0 5,000 hour B10 life		
			1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm
1,000	Uniform	1.5748	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308
	Variable	1.5748	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308
3,000	Uniform	1.7717	21309	21309	22309	21309	21309	21309	21309	21309	21309	21309	21309	21309	21309	21309	21309
	Variable		22308	22308	22309	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308	22308
5,000	Uniform	1.9685	22310	22310	22310	21310	22310	22310	21310	22310	22310	21310	21310	21310	21310	21310	21310
	Variable		22309	22310	22310	22309	22310	22310	22308	22309	22310	22308	22308	22309	22308	22308	22308
7,000	Uniform	2.3622	22312	22312	22312	21312	22312	22312	21312	22312	22312	21312	21312	21312	21312	21312	21312
	Variable		22310	22311	22312	22310	22311	22312	22309	22310	22311	22308	22309	22310	22308	22308	22309
9,000	Uniform	2.7559	22314	22314	22314	21314	22314	22314	21314	22314	22314	21314	21314	21314	21314	21314	21314
	Variable		22311	22313	22314	22311	22312	22314	22310	22311	22312	22310	22310	22311	22309	22310	22310
10,000	Uniform	2.7559	22314	22314	22314	22314	22314	22314	21314	22314	22314	21314	21314	22314	21314	21314	21314
	Variable		22312	22314	22314	22311	22313	22314	22311	22312	22314	22310	22311	22312	22309	22310	22310
12,000	Uniform	3.1496	22316	22316	22316	22316	22316	22316	22316	22316	22316	22316	22316	22316	22216	22316	22316
	Variable		22314	22314	22316	22313	22314	22315	22312	22314	22314	22310	22312	22313	22310	22310	22311
15,000	Uniform	3.5433	22318	22318	22318	22318	22318	22318	22318	22318	22318	22218	22318	22318	22218	22218	22318
	Variable		22314	22316	22318	22314	22316	22317	22314	22314	22316	22312	22314	22314	22310	22312	22313
18,000	Uniform	3.7402	22319	22319	22319	22319	22319	22319	22319	22319	22319	22219	22319	22319	22219	22219	22319
	Variable		22316	22318	22319	22315	22317	22318	22314	22316	22318	22313	22314	22316	22311	22313	22314
20,000	Uniform	3.9370	23220A	22320	22320	23220A	22320	22320	23220A	23220A	22320	22220	23220A	23220A	22220	22220	22220
	Variable		22317	22318	22320	22316	22318	22319	22315	22317	22318	22314	22315	22316	22312	22314	22314
24,000	Uniform	4.3307	23222A	22322	22322	23222A	22322	22322	22222	23222A	22322	22222	22222	23222A	22222	22222	22222
	Variable		22318	22320	22322	22318	22319	22322	22316	22318	22320	22314	22316	22318	22314	22314	22316
30,000	Uniform	4.7244	23224A	22324	22324	23224A	22324	22324	22224	23224A	22324	22224	22224	23224A	22224	22224	22224
	Variable		22320	22322	22324	22319	22322	22324	22318	22320	22322	22316	22318	22320	22314	22316	22318
40,000	Uniform	5.5118	23228A	22328	22328	23228A	22328	22328	22228	23228A	22328	22228	22228	23228A	22228	22228	22228
	Variable		22324	22326	22328	22322	22324	22326	22320	22324	22324	22318	22320	22322	22317	22318	22320
50,000	Uniform	6.2992	23232A	22332	22332	22232	23232A	22332	22232	23232A	22332	22232	22232	23232A	22232	22232	22232
	Variable		22326	22330	22332	22324	22328	22330	22324	22326	22328	22320	22324	22324	22318	22320	22322
60,000	Uniform	7.0866	23236A	22336	22336	23236A	23236A	22336	22236	23236A	23236A	22236	22236	23236A	22236	22236	22236
	Variable		22328	22334	22336	22326	22332	22334	22324	22328	22332	22322	22324	22328	22320	22322	22324
70,000	Uniform	7.8740	23240A	23240A	22340	22240	23240A	22340	22240	23240A	23240A	22240	22240	23240A	22240	22240	22240
	Variable		22332	22336	22340	22330	22334	22338	22326	22332	22334	22324	22326	22330	22322	22324	22326
80,000	Uniform	8.6614	22244	23244	22344	22244	23244	23244	22244	22244	23244	22244	22244	22244	22244	22244	22244
	Variable		22334	22338	22344	22332	22336	22340	22330	22334	22338	22326	22330	22334	22324	22326	22328
90,000	Uniform	9.4488	23148	23248	23248	23148	23248	23248	23148	23148	23248	23148	23148	23148	23148	23148	23148
	Variable		22336	23152	23248	22334	22338	23248	22332	22336	22340	22328	22332	22334	22324	22328	22330
100,000	Uniform	10.2362	23152	23252	23252	23152	23152	23252	23152	23152	23252	23152	23152	23152	23052	23152	23152
	Variable		22338	23248	23252	22336	23152	23252	22334	22338	23248	22330	22334	22338	22326	22330	22332

TABLE 34-VII BEARINGS FOR BRIDGE AND TROLLEY TRACK WHEEL AXLES

THE TORRINGTON CO. — BANTAM BEARINGS DIVISION

Box load	[illegible]	Bearing bore	Class 4 40,000 hour B10 life			Class 3 30,000 hour B10 life			Class 2 20,000 hour B10 life			Class 1 10,000 hour B10 life			Class 0 5,000 hour B10 life		
			1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm
1,000	Uniform	1.5748	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23
	Variable		40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23	40SD23
3,000	Uniform	1.7717	45SD23	45SD23	45SD23	45SD23	45SD23	45SD23	45SD23	45SD23	45SD23	45SD23	45SD23	45SD23	45SD23	45SD23	45SD23
	Variable		40SD23 (1.5748)	40SD23 (1.5748)	45SD23 (1.7717)	40SD23 (1.5748)	40SD23 (1.5748)	45SD23 (1.7717)	40SD23 (1.5748)	40SD23 (1.5748)	40SD23 (1.5748)	40SD23 (1.5748)	40SD23 (1.5748)	40SD23 (1.5748)	40SD23 (1.5748)	40SD23 (1.5748)	40SD23 (1.5748)
5,000	Uniform	2.1654	55SD23	55SD23	55SD23	55SD23	55SD23	55SD23	55SD23	55SD23	55SD23	55SD23	55SD23	55SD23	55SD23	55SD23	55SD23
	Variable		50SD23 (1.9685)	50SD23 (1.9685)	55SD23 (2.1654)	50SD23 (1.9685)	50SD23 (1.9685)	55SD23 (2.1654)	45SD23 (1.7717)	50SD23 (1.9685)	50SD23 (1.9685)	40SD23 (1.5748)	45SD23 (1.7717)	50SD23 (1.9685)	40SD23 (1.5748)	40SD23 (1.5748)	45SD23 (1.7717)
7,000	Uniform	2.7559	70SD23	70SD23	70SD23	70SD23	70SD23	70SD23	70SD23	70SD23	70SD23	70SD23	70SD23	70SD23	70SD23	70SD23	70SD23
	Variable		55SD23 (2.1654)	60SD23 (2.3622)	70SD23 (2.7559)	55SD23 (2.1654)	60SD23 (2.3622)	65SD23 (2.5591)	50SD23 (1.9685)	55SD23 (2.1654)	60SD23 (2.3622)	50SD23 (1.9685)	50SD23 (1.9685)	55SD23 (2.1654)	45SD23 (1.7717)	45SD23 (1.7717)	50SD23 (1.9685)
9,000	Uniform	2.9528	75SD23	75SD23	75SD23	75SD23	75SD23	75SD23	75SD23	75SD23	75SD23	75SD23	75SD23	75SD23	75SD23	75SD23	75SD23
	Variable		65SD23 (2.5591)	70SD23 (2.7559)	75SD23 (2.9528)	60SD23 (2.3622)	70SD23 (2.7559)	70SD23 (2.7559)	60SD23 (2.3622)	60SD23 (2.3622)	70SD23 (2.7559)	50SD23 (1.9685)	55SD23 (2.1654)	60SD23 (2.3622)	50SD23 (1.9685)	50SD23 (1.9685)	55SD23 (2.1654)
10,000	Uniform	3.1496	80SD23	80SD23	80SD23	80SD23	80SD23	80SD23	80SD23	80SD23	80SD23	80SD23	80SD23	80SD23	80SD23	80SD23	80SD23
	Variable		70SD23 (2.7559)	70SD23 (2.7559)	80SD23 (3.14961)	65SD23 (2.5591)	70SD23 (2.7559)	75SD23 (2.9528)	60SD23 (2.3622)	70SD23 (2.7559)	70SD23 (2.7559)	55SD23 (2.1654)	60SD23 (2.3622)	65SD23 (2.5591)	50SD23 (1.9685)	55SD23 (2.1654)	60SD23 (2.3622)
12,000	Uniform	3.5433	90SD23	90SD23	90SD23	90SD23	90SD23	90SD23	90SD23	90SD23	90SD23	90SD23	90SD23	90SD23	90SD23	90SD23	90SD23
	Variable		70SD23 (2.7559)	80SD23 (3.1496)	90SD23 (3.5433)	70SD23 (2.7559)	80SD23 (3.1496)	85SD23 (3.3465)	70SD23 (2.7559)	70SD23 (2.7559)	80SD23 (3.1496)	60SD23 (2.3622)	65SD23 (2.5591)	70SD23 (2.7559)	55SD23 (2.1654)	60SD23 (2.3622)	65SD23 (2.5591)
15,000	Uniform	3.7402	95SD23	95SD23	95SD23	95SD23	95SD23	95SD23	95SD23	95SD23	95SD23	95SD23	95SD23	95SD23	95SD23	95SD23	95SD23
	Variable		80SD23 (3.1496)	90SD23 (3.5433)	95SD23 (3.7402)	80SD23 (3.1496)	85SD23 (3.3465)	90SD23 (3.5433)	70SD23 (2.7559)	80SD23 (3.1496)	90SD23 (3.5433)	70SD23 (2.7559)	70SD23 (2.7559)	80SD23 (3.1496)	60SD23 (2.3622)	65SD23 (2.5590)	70SD23 (2.7559)
18,000	Uniform	3.9370	100SD23	100SD23	100SD23	100SD23	100SD23	100SD23	100SD23	100SD23	100SD23	100SD23	100SD23	100SD23	100SD23	100SD23	100SD23
	Variable		90SD23 (3.5433)	95SD23 (3.7402)	100SD23 (3.9370)	85SD23 (3.3465)	95SD23 (3.7402)	100SD23 (3.9370)	80SD23 (3.1496)	90SD23 (3.5433)	95SD23 (3.7402)	70SD23 (2.7559)	80SD23 (3.1496)	85SD23 (3.3465)	70SD23 (2.7559)	70SD23 (2.7559)	80SD23 (3.1496)
20,000	Uniform	4.3307	110SD23	110SD23	110SD23	110SD23	110SD23	110SD23	110SD23	110SD23	110SD23	110SD31	110SD23	110SD23	110SD31	110SD31	110SD31
	Variable		95SD23 (3.7402)	100SD23 (3.9370)	110SD23 (4.3307)	90SD23 (3.5433)	100SD23 (3.9370)	100SD23 (3.9370)	85SD23 (3.3465)	90SD23 (3.5433)	100SD23 (3.9370)	80SD23 (3.1496)	85SD23 (3.3465)	90SD23 (3.5433)	70SD23 (2.7559)	75SD23 (2.9528)	80SD23 (3.1496)
24,000	Uniform	4.7244	120SD23	120SD23	120SD23	120SD23	120SD23	120SD23	120SD23	120SD23	120SD23	120SD31	120SD31	120SD23	120SD31	120SD31	120SD31
	Variable		100SD23 (3.9370)	110SD23 (4.3307)	120SD23 (4.7244)	100SD23 (3.9370)	110SD23 (4.3307)	110SD23 (4.3307)	95SD23 (3.7402)	100SD23 (3.9370)	110SD23 (4.3307)	85SD23 (3.3465)	90SD23 (3.5433)	100SD23 (3.9370)	75SD23 (2.9528)	85SD23 (3.3465)	90SD23 (3.5433)
30,000	Uniform	5.1181	130SD23	130SD23	130SD23	130SD23	130SD23	130SD23	130SD23	130SD23	130SD23	130SD31	130SD23	130SD23	130SD31	130SD31	130SD31
	Variable		110SD23 (4.3307)	120SD23 (4.7244)	130SD23 (5.1181)	110SD23 (4.3307)	120SD23 (4.7244)	130SD23 (5.1181)	100SD23 (3.9370)	110SD23 (4.3307)	120SD23 (4.7244)	95SD23 (3.7402)	100SD23 (3.9370)	110SD23 (4.3307)	85SD23 (3.3465)	90SD23 (3.5433)	100SD23 (3.9370)
40,000	Uniform	6.2992	160SD23	160SD23	160SD23	160SD23	160SD23	160SD23	160SD31	160SD23	160SD23	160SD31	160SD31	160SD23	160SD31	160SD31	160SD31
	Variable		130SD23 (5.1181)	140SD23 (5.5118)	160SD23 (6.2992)	120SD23 (4.7244)	140SD23 (5.5118)	150SD23 (5.9055)	120SD23 (4.7244)	130SD23 (5.1181)	140SD23 (5.5118)	110SD23 (4.3307)	120SD23 (4.7244)	120SD23 (4.7244)	100SD23 (3.9370)	100SD23 (3.9370)	110SD23 (4.3307)
50,000	Uniform	7.0866	180SD23	180SD23	180SD23	180SD23	180SD23	180SD23	180SD31	180SD23	180SD23	180SD31	180SD31	180SD23	180SD31	180SD31	180SD31
	Variable		150SD23 (5.9055)	160SD23 (6.2992)	180SD23 (7.0866)	140SD23 (5.5118)	160SD23 (6.2992)	170SD23 (6.6929)	130SD23 (5.1181)	150SD23 (5.9055)	160SD23 (6.2992)	120SD23 (4.7244)	130SD23 (5.1181)	140SD23 (5.5118)	110SD23 (4.3307)	120SD23 (4.7244)	120SD23 (4.7244)
60,000	Uniform	7.8740	200SD23	200SD23	200SD23	200SD23	200SD23	200SD23	200SD31	200SD23	200SD23	200SD31	200SD31	200SD23	200SD31	200SD31	200SD31
	Variable		170SD23 (6.6929)	180SD23 (7.0866)	200SD23 (7.8740)	160SD23 (6.2992)	170SD23 (6.6929)	190SD23 (7.4803)	150SD23 (5.9055)	160SD23 (6.2992)	180SD23 (7.0866)	130SD23 (5.1181)	140SD23 (5.5118)	160SD23 (6.2992)	120SD23 (4.7244)	120SD23 (4.7244)	140SD23 (5.5118)
70,000	Uniform	8.6614	220SD32	220SD32	220SD23	220SD31	220SD32	220SD23	220SD31	220SD32	220SD32	220SD31	220SD31	220SD31	220SD31	220SD31	220SD31
	Variable		180SD23 (7.0866)	200SD23 (7.8740)	220SD23 (8.6614)	170SD23 (6.6929)	190SD23 (7.4803)	220SD23 (8.6614)	160SD23 (6.2992)	170SD23 (6.6929)	190SD23 (7.4803)	140SD23 (5.5118)	160SD23 (6.2992)	170SD23 (6.6929)	120SD23 (4.7244)	140SD23 (5.5118)	150SD23 (5.9055)
80,000	Uniform	9.4488	240SD32	240SD32	240SD23	240SD31	240SD32	240SD32	240SD31	240SD32	240SD32	240SD31	240SD31	240SD31	240SD31	240SD31	240SD31
	Variable		190SD23 (7.4803)	220SD23 (8.6614)	240SD23 (9.4488)	180SD23 (7.0866)	200SD23 (7.8740)	220SD23 (8.6614)	170SD23 (6.6929)	190SD23 (7.4803)	220SD23 (8.6614)	150SD23 (5.9055)	170SD23 (6.6929)	180SD23 (7.0866)	130SD23 (5.1181)	150SD23 (5.9055)	170SD23 (6.6929)
90,000	Uniform	10.2362	260SD31	260SD32	260SD23	260SD31	260SD32	260SD32	260SD31	260SD31	260SD32	260SD31	260SD31	260SD31	260SD31	260SD31	260SD31
	Variable		220SD23 (8.6614)	240SD23 (9.4488)	260SD23 (10.2362)	200SD23 (7.8740)	220SD23 (8.6614)	240SD23 (9.4488)	180SD23 (7.0866)	200SD23 (7.8740)	220SD23 (8.6614)	160SD23 (6.2992)	180SD23 (7.0866)	200SD23 (7.8740)	150SD23 (5.9055)	160SD23 (6.2992)	170SD23 (6.6929)
100,000	Uniform	11.0236	280SD31	280SD32	280SD23	280SD31	280SD32	280SD32	280SD31	280SD31	280SD32	280SD31	280SD31	280SD31	280SD31	280SD31	280SD31
	Variable		220SD23 (8.6614)	260SD23 (10.2362)	280SD23 (11.0236)	220SD23 (8.6614)	240SD23 (9.4488)	260SD23 (10.2362)	200SD23 (7.8740)	220SD23 (8.6614)	240SD23 (9.4488)	170SD23 (6.6929)	190SD23 (7.4803)	220SD23 (8.6614)	150SD23 (5.9055)	170SD23 (6.6929)	180SD23 (7.0866)

TABLE 34-VIII — BEARINGS FOR BRIDGE AND TROLLEY TRACK WHEEL AXLES

TYSON BEARING CORPORATION

Load per box, lb		Bore, in.	Class 4 40,000 hour B10 life			Class 3 30,000 hour B10 life			Class 2 20,000 hour B10 life			Class 1 10,000 hour B10 life			Class 0 5,000 hour B10 life		
			1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm
1,000	Uniform	0.7500	09078-09194	09078-09194	09078-09194	09078-09194	09078-09194	09078-09194	09078-09194	09078-09194	09078-09194	09078-09194	09078-09194	09078-09194	09078-09194	09078-09194	09078-09194
	Variable		09078-09194 (0.7500)	09078-09194 (0.7500)	09078-09194 (0.7500)	09078-09194 (0.7500)	09078-09194 (0.7500)	09078-09194 (0.7500)	09078-09194 (0.7500)	09078-09194 (0.7500)	09078-09194 (0.7500)	09078-09194 (0.7500)	09078-09194 (0.7500)	09078-09194 (0.7500)	09078-09194 (0.7500)	09078-09194 (0.7500)	09078-09194 (0.7500)
3,000	Uniform	1.1250	15112-15250	15112-15250	2689-2631	15112-15250	15112-15250	2689-2631	15112-15250	15112-15250	15112-15250	15112-15250	15112-15250	15112-15250	15112-15250	15112-15250	15112-15250
	Variable		15100-15250 (1.0000)	15112-15250 (1.1250)	28118-28315 (1.1875)	15100-15250 (1.0000)	15112-15250 (1.1250)	28118-28315 (1.1875)	15100-15250 (1.0000)	15112-15250 (1.1250)	15112-15250 (1.1250)	15100-15250 (1.0000)	15100-15250 (1.0000)	15112-15250 (1.1250)	15100-15250 (1.0000)	15100-15250 (1.0000)	15100-15250 (1.0000)
5,000	Uniform	1.3125	2785-2720	2785-2720	3196-3120	2785-2720	2785-2720	3196-3120	2785-2720	2785-2720	2785-2720	2785-2720	2785-2720	2785-2720	2785-2720	2785-2720	2785-2720
	Variable		2690-2631 (1.1562)	2785-2720 (1.3125)	3196-3120 (1.3125)	2690-2631 (1.1562)	2785-2720 (1.3125)	3196-3120 (1.3125)	2690-2631 (1.1562)	2690-2631 (1.1562)	2785-2720 (1.3125)	1985-1931 (1.1250)	28118-28315 (1.1875)	2580-2523 (1.2500)	15112-15250 (1.1250)	1985-1931 (1.1250)	2690-2631 (1.1562)
7,000	Uniform	1.5000	3490-3420	3381-3320	465-N-453-A	2788-2720	3490-3420	3580-3525	2786-2720	3381-3320	3381-3320	16150-16282	2788-2720	2788-2720	28150-28315	16150-16282	2788-2720
	Variable		3478-3420 (1.3750)	3379-3320 (1.3750)	465-N-453-A (1.5000)	2786-2720 (1.3750)	3478-3420 (1.3750)	3580-3525 (1.5000)	335-S-332 (1.3125)	3196-3120 (1.3125)	3379-3320 (1.3750)	16131-16282 (1.3125)	335-S-332 (1.3125)	2786-2720 (1.3750)	14132-14274 (1.3125)	16131-16282 (1.3125)	16131-16282 (1.3125)
9,000	Uniform	1.6250	447-432	526-522	59162-59412	3383-3320	464-453-A	526-522	419-414	3577-3525	464-453-A	336-332	419-414	3383-3320	336-332	336-332	3383-3320
	Variable		435-432 (1.7500)	527-522 (1.7500)	59187-59412 (1.8750)	3383-3320 (1.6250)	460-453-A (1.7500)	527-522 (1.7500)	419-414 (1.6250)	3577-3525 (1.6250)	460-453-A (1.7500)	336-332 (1.6250)	419-414 (1.6250)	3383-3320 (1.6250)	16150-16282 (1.5000)	336-332 (1.6250)	3383-3320 (1.6250)
10,000	Uniform	2.0000	455-453-A	529-522	555-552-A	3780-3720	529-522	537-532-A	3780-3720	455-453-A	529-522	398-394-A	3780-3720	3780-3720	375-372-A	398-394-A	3780-3720
	Variable		463-453-A (1.8750)	528-522 (1.8750)	555-552-A (2.0000)	3778-3720 (1.8750)	528-522 (1.8750)	537-532-A (2.0000)	3778-3720 (1.8750)	463-453-A (1.8750)	528-522 (1.8750)	398-394-A (2.0000)	3778-3720 (1.8750)	3778-3720 (1.8750)	375-372-A (2.0000)	398-394-A (2.0000)	3778-3720 (1.8750)
12,000	Uniform	2.1250	539-532-A	624-612	636-632	456-453-A	557-S-552-A	4553-4520	456-453-A	539-532-A	557-S-552-A	456-453-A	456-453-A	539-532-A	456-453-A	456-453-A	456-453-A
	Variable		529-522 (2.0000)	565-563 (2.5000)	635-632 (2.2500)	475-472 (2.1653)	555-S-552-A (2.2500)	623-612 (2.2500)	456-453-A (2.1250)	539-532-A (2.1250)	555-S-552-A (2.2500)	3767-3720 (2.0625)	456-453-A (2.1250)	539-532 (2.1250)	398-394-A (2.0000)	3780-3720 (2.0000)	3780-3720 (2.0000)
15,000	Uniform	2.5000	565-563	655-N-652	745-S-742	559-552-A	639-632	5584-5520	559-552-A	565-563	639-632	483-472	559-552-A	559-552-A	477-472	477-472	559-552-A
	Variable		623-612 (2.2500)	655-N-652 (2.5000)	5760-5720 (3.0000)	559-552-A (2.5000)	639-632 (2.5000)	5584-5520 (2.5000)	529-522 (2.0000)	565-563 (2.5000)	639-632 (2.5000)	462-453-A (2.2500)	529-522 (2.0000)	559-552-A (2.5000)	3767-3720 (2.0625)	462-453-A (2.2500)	529-522 (2.0000)
18,000	Uniform	3.0000	659-652	5760-5720	755-752	575-572	5760-5720	748-S-742	575-572	659-652	5760-5720	495-A-493	575-572	659-652	575-572	495-A-493	575-572
	Variable		659-652 (3.0000)	748-S-742 (3.0000)	755-752 (3.0000)	595-592-A (3.2500)	677-672 (3.3750)	748-S-742 (3.0000)	568-563 (2.9062)	659-652 (3.0000)	5760-5720 (3.0000)	495-A-493 (3.0000)	568-563 (2.9062)	645-632 (2.8125)	482-472 (2.7500)	495-A-493 (3.0000)	568-563 (2.9062)
20,000	Uniform	3.7500	683-672	777-772	777-772	52375-52618	683-672	777-772	594-592-A	683-672	777-772	594-592-A	594-592-A	683-672	594-592-A	594-592-A	594-592-A
	Variable		683-672 (3.7500)	760-752 (3.5625)	777-772 (3.7500)	52375-52618 (3.7500)	683-672 (3.7500)	760-752 (3.5625)	594-592-A (3.7500)	683-672 (3.7500)	760-752 (3.5625)	69354-69630 (3.5430)	52375-52618 (3.7500)	683-672 (3.7500)	69354-69630 (3.5430)	69354-69630 (3.5430)	594-592-A (3.7500)
24,000	Uniform	4.0000	780-772	780-772	861-854	687-682	780-772	861-854	687-682	780-772	780-772	52400-52618	687-682	780-772	52400-52618	52400-52618	52400-52618
	Variable		780-772 (4.0000)	780-772 (4.0000)	861-854 (4.0000)	687-682 (4.0000)	780-772 (4.0000)	861-854 (4.0000)	687-682 (4.0000)	780-772 (4.0000)	780-772 (4.0000)	52400-52618 (4.0000)	687-682 (4.0000)	780-772 (4.0000)	68450-68712 (4.5000)	52400-52618 (4.0000)	52400-52618 (4.0000)
30,000	Uniform	4.7500	795-792	873-N-872-N	873-N-872-N	795-792	873-N-872-N	873-N-872-N	795-792	795-792	873-N-872-N	795-792	795-792	795-792	795-792	795-792	795-792
	Variable		795-792 (4.7500)	873-N-872-N (4.7500)	873-N-872-N (4.7500)	71450-71750 (4.5000)	861-854 (4.0000)	873-N-872-N (4.7500)	786-772 (4.1250)	71450-71750 (4.5000)	861-854 (4.0000)	687-672 (4.0000)	786-772 (4.1250)	71450-71750 (4.5000)	687-672 (4.0000)	687-672 (4.0000)	786-772 (4.1250)
40,000	Uniform	5.0000	875-N-872-N	95500-95925	154050-N-154107-N	875-N-872-N	875-N-872-N	95500-95925	74500-74850	875-N-872-N	875-N-872-N	796-N-792	74500-74850	875-N-872-N	796-N-792	796-N-792	796-N-792
	Variable		875-N-872-N (5.0000)	95500-95925 (5.0000)	154050-N-154107-N (5.0000)	875-N-872-N (5.0000)	875-N-872-N (5.0000)	95500-95925 (5.0000)	74500-74850 (5.0000)	875-N-872-N (5.0000)	938-932 (4.5000)	71450-71750 (4.5000)	74500-74850 (5.0000)	875-N-872-N (5.0000)	71450-71750 (4.5000)	71450-71750 (4.5000)	71450-71750 (4.5000)
50,000	Uniform	5.5000	99550-99100	154054-N-154107-N	450551-451212	880-N-872-N	99550-99100	154054-N-154107-N	880-N-872-N	99550-99100	154054-N-154107-N	74550-74850	880-N-872-N	880-N-872-N	74550-74850	74550-74850	880-N-872-N
	Variable		95525-95925 (5.2500)	154054-N-154107-N (5.5000)	540502-541162 (5.0000)	880-N-872-N (5.5000)	99550-99100 (5.5000)	154054-N-154107-N (5.5000)	880-N-872-N (5.5000)	95525-95925 (5.2500)	154054-N-154107-N (5.5000)	74550-74850 (5.5000)	880-N-872-N (5.5000)	95525-95925 (5.2500)	799-792 (5.0625)	74550-74850 (5.5000)	880-N-872-N
60,000	Uniform	6.0000	158600-N-158122-N	158600-N-158122-N	450601-451212	99600-99100	158600-N-158122-N	450601-451212	99600-99100	158600-N-158122-N	158600-N-158122-N	89600-N-89105-N	99600-99100	99600-99100	89600-N-89105-N	89600-N-89105-N	99600-99100
	Variable		94625-N 94113 (6.2500)	158600-N-158122-N (6.0000)	450601-451212 (6.0000)	94625-94113 (6.2500)	158600-N-158122-N (6.0000)	450601-451212 (6.0000)	99600-99100 (6.0000)	94625-94113 (6.2500)	158600-N-158122-N (6.0000)	89600-N-89105-N (6.0000)	99600-99100 (6.0000)	94625-94113 (6.2500)	89600-N-89105-N (6.0000)	89600-N-89105-N (6.0000)	99600-99100 (6.0000)
70,000	Uniform	6.5000	158650-N-158122-N	610650-N-611425-N	610650-N-611425-N	158650-N-158122-N	158650-N-158122-N	610650-N-611425-N	94650-N-94113	158650-N-158122-N	610650-N-611425-N	94650-N-94113	94650-N-94113	158650-N-158122-N	89650-N-89105-N	94650-N-94113	94650-N-94113
	Variable		158650-N-158122-N (6.5000)	450601-451212 (6.0000)	470078-470133 (7.0000)	158650-N-158122-N (6.5000)	219068-219122 (6.8750)	420701-421437 (7.0000)	94650-N-94113 (6.5000)	158650-N-158122-N (6.5000)	450601-451212 (6.0000)	99600-99100 (6.0000)	94650-N-94113 (6.5000)	158650-N-158122-N (6.5000)	89650-N-89105-N (6.5000)	99600-99100 (6.0000)	99600-99100 (6.0000)
80,000	Uniform	7.0000	420701-421437	470078-470113		420701-421437	420701-421437	470078-470113	420701-421437	420701-421437	420701-421437	94700-94113	94700-94113	420701-421437	94700-94113	94700-94113	94700-94113
	Variable		219068-219122 (6.8750)	470078-470113 (7.0000)	610650-N-611425-N (6.5000)	219068-219122 (6.8750)	420701-421437 (7.0000)	610650-N-611425-N (6.5000)	158650-N-158122-N (6.5000)	219068-219122 (6.8750)	420701-421437 (7.0000)	94700-94113 (7.0000)	158650-N-158122-N (6.5000)	219068-219122 (6.8750)	89650-N-89105-N (6.5000)	94700-94113 (7.0000)	94700-94113 (7.0000)
90,000	Uniform	8.0000	420801-421437			420801-421437	420801-421437		420801-421437	420801-421437		93800-93125	420801-421437	420801-421437	93800-93125	93800-93125	93800-93125
	Variable		420801-421437 (8.0000)	430900-N-431575 (9.0000)		420801-421437 (8.0000)	430900-N-431575 (9.0000)		420801-421437 (8.0000)	420801-421437 (8.0000)	430900-N-431575 (9.0000)	93800-93125 (8.0000)	420801-421437 (8.0000)	420801-421437 (8.0000)	93800-93125 (8.0000)	93800-93125 (8.0000)	93800-93125 (8.0000)
100,000	Uniform	9.0000	430900-N-431575			430900-N-431575			430900-N-431575	430900-N-431575		430900-N-431575	430900-N-431575	430900-N-431575	430900-N-431575	430900-N-431575	430900-N-431575
	Variable		430900-N-431575 (9.0000)	295950-295193 (9.5000)	295950-295193 (9.5000)	430900-N-431575 (9.0000)	295950-295193 (9.5000)	295950-295193 (9.5000)	430900-N-431575 (9.0000)	430900-N-431575 (9.0000)	295950-295193 (9.5000)	221026-221575 (10.2500)	430900-N-431575 (9.0000)	430900-N-431575 (9.0000)	221026-221575 (10.2500)	221026-221575 (10.2500)	430900-N-431575 (9.0000)

35. Bearing Brackets and Housings:

A. Bearing brackets if not integral with frame must be kept in alinement by male and female joints or equally effective method.

B. Where shafting is geared together, the brackets supporting the bearing housings shall be integral and shall be located as close as possible to gear and pinion.

C. Heavy caps shall be provided with eye bolts for lifting.

36. Gearing:

A. Gearing shall be straight spur, herringbone, helical, or worm as specified on the information sheet. Gearing shall be designed and manufactured to comply to current AGMA gear proportion standards unless otherwise stated.

1. Where worm gear drive is specified, the design and loading shall be in accordance with standards set up by the manufacturer of the worm gear.

2. Formulae and calculations for spur gears contained in this section cover 20 degree full depth, 20 degree stub, and 14½ degree full depth tooth forms. Tooth form shall be that selected by crane manufacturer unless otherwise specified on information sheets.

B. Upon release of AGMA Standard No. 241.01-Steel Gear Blanks, by the AGMA, materials for gear and pinion blanks shall be made to conform to the following items in this specification:

1. Material	Heat treated class	Carburized class	Surface hardened class
Forged or fabricated alloy steel	A-2	A-3	A-4
Forged or fabricated carbon steel	B-2	B-3	B-4
Cast alloy steel	C-2	C-3	C-4
Cast carbon steel	D-2	D-3	...

2. Heat treated gears, class 2, can be used to obtain hardness up to about 500 Brinell.

3. Carburized material should have a depth of case which is at least one-sixth the thickness of the tooth at the pitch line.

4. The following specification will govern prior to the release of AGMA No. 241.01. Plain pinions shall be made when possible from forgings. Gears shall, preferably, be made from fabricated steel sections, welded, or solid wrought steel blanks. Gears and pinions of design and size not suitable for forging, or gears for which suitable wrought steel blanks are not obtainable shall be fabricated by welding or cast of steel in accordance with the ASTM Specifications for Mild-to Medium-Strength Carbon-Steel Castings for General Application (Tentative), Designation A 27, latest issue. Castings shall be free from blowholes and other injurious defects.

C. Bores for gears and pinions shall be finish machined or ground to size after heat treatment.

D. Journal and bearing fits on heat-treated shafts shall be ground to size after heat treatment.

E. All keyways shall be made to conform to AGMA Keyway Standard No. 261.01., (ASA B6.6).

TABLE 34-IX — BEARINGS FOR BRIDGE AND TROLLEY TRACK WHEEL AXLES

THE TIMKEN ROLLER BEARING CO.

Box load		Bearing bore	Class 4 40,000 hour B10 life			Class 3 30,000 hour B10 life			Class 2 20,000 hour B10 life			Class 1 10,000 hour B10 life			Class 0 5,000 hour B10 life		
			1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm	1-30 rpm	31-60 rpm	61-100 rpm
1,000	Uniform	1.5000	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284
3,000	Uniform	1.7500	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326
5,000	Uniform	2.1875	29680-29822	29680-29822	29680-29822	29680-29822	29680-29822	29680-29822	29680-29822	29680-29822	29680-29822	29680-29822	29680-29822	29680-29822	29680-29822	29680-29822	29680-29822
7,000	Uniform	2.6250	3994-3920	3994-3920	479-472A	3994-3920	3994-3920	3994-3920	3994-3920	3994-3920	3994-3920	3994-3920	3994-3920	3994-3920	3994-3920	3994-3920	3994-3920
8,000	Uniform	3.0000	495A-493	495A-493	47680-47620	495A-493	495A-493	47680-47620	495A-493	495A-493	495A-493	495A-493	495A-493	495A-493	495A-493	495A-493	495A-493
10,000	Uniform	3.2500	495-493	495-493	580-572	495-493	495-493	495-493	495-493	495-493	495-493	495-493	495-493	495-493	495-493	495-493	495-493
12,000	Uniform	3.5000	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A
15,000	Uniform	3.7500	594-592A	594-592A	683-672	594-592A	594-592A	683-672	594-592A	594-592A	594-592A	594-592A	594-592A	594-592A	594-592A	594-592A	594-592A
18,000	Uniform	4.0000	687-672	687-672	780-772	687-672	687-672	780-772	687-672	687-672	687-672	687-672	687-672	687-672	687-672	687-672	687-672
20,000	Variable		64433-64700 (4.3304)	71425-71750 (4.2500)	71425-71750 (4.2500)	56425-56650 (4.2500)	64433-64700 (4.3304)	71425-71750 (4.2500)	56425-56650 (4.2500)	64433-64700 (4.3304)	64433-64700 (4.3304)	56425-56650 (4.2500)	56425-56650 (4.2500)	56425-56650 (4.2500)	56425-56650 (4.2500)	56425-56650 (4.2500)	56425-56650 (4.2500)
24,000	Uniform	4.5000	64450-64700	71450-71750	938-932	64450-64700	71450-71750	64450-64700	64450-64700	71450-71750	71450-71750	64450-64700	64450-64700	64450-64700	64450-64700	64450-64700	64450-64700
30,000	Uniform	5.0000	67388-67320	95500-95925	67388-67320	95500-95925	95500-95925	95500-95925	48290-48220	67388-67320	95500-95925	48290-48220	67388-67320	48290-48220	48290-48220	48290-48220	48290-48220
40,000	Uniform	5.7500	82576-82950	HM231140-HM231110	99575-99100	82576-82950	HM231140-HM231110	HM231140-HM231110	82576-82950	HM231140-HM231110	HM231140-HM231110	82576-82950	82576-82950	82576-82950	82576-82950	82576-82950	82576-82950
50,000	Uniform	6.5000	HM237535-HM237510	HM237535-HM237510	EE219065-219122	HM237535-HM237510	HM237535-HM237510	EE219065-219122	M235145-M235113	HM237535-HM237510	HM237535-HM237510	M235145-M235113	M235145-M235113	HM237535-HM237510	M235145-M235113	M235145-M235113	M235145-M235113
60,000	Variable		93750-93125 (7.5000)	H239649NA-H239610 (7.3750)	H239649NA-H239610 (7.3750)	93750-93125 (7.5000)	H239649NA-H239610 (7.3750)	H239649NA-H239610 (7.3750)	93750-93125 (7.5000)	H239649NA-H239610 (7.3750)	H239649NA-H239610 (7.3750)	93750-93125 (7.5000)	93750-93125 (7.5000)	93750-93125 (7.5000)	87885-87820 (7.5000)	87885-87820 (7.5000)	93750-93125 (7.5000)
70,000	Uniform	8.0000	EE420801-421437	EE420801-421437	EE420801-421437	93600-93125	EE420801-421437	EE420801-421437	93600-93125	EE420801-421437	EE420801-421437	EE420801-421437	93600-93125	EE420801-421437	93600-93125	93600-93125	93600-93125
80,000	Uniform	9.0000	EE529091D-529157	EE529091D-529157	EE700091-700167	EE529091D-529157	EE529091D-529157	EE430900-431575	96900-96140	EE529091D-529157	EE529091D-529157	96900-96140	96900-96140	EE529091D-529157	96900-96140	96900-96140	96900-96140
90,000	Variable		M249749-M249710 (10.000)	H247549-H247510 (9.2500)	H247549-H247510 (9.2500)	M249749-M249710 (10.000)	H247549-H247510 (9.2500)	H247549-H247510 (9.2500)	EE125095-125145 (9.5000)	M249749-M249710 (10.000)	H247549-H247510 (9.2500)	EE125095-125145 (9.5000)	M249749-M249710 (10.000)	EE125095-125145 (9.5000)	EE125095-125145 (9.5000)	EE125095-125145 (9.5000)	EE125095-125145 (9.5000)
100,000	Variable		H247549-H247510 (9.2500)	H247549-H247510 (9.2500)	H247549-H247510 (9.2500)	M249749-M249710 (10.000)	H247549-H247510 (9.2500)	H247549-H247510 (9.2500)	M249749-M249710 (10.000)	H247549-H247510 (9.2500)	H247549-H247510 (9.2500)	EE125095-125145 (9.5000)	M249749-M249710 (10.000)	M249749-M249710 (10.000)	EE125095-125145 (9.5000)	EE125095-125145 (9.5000)	M249749-M249710 (10.000)

F. Durability and strength rating of the teeth of gears and pinions shall not exceed those derived from the application of AGMA spur gear standards to crane gearing included under paragraph J of this section. If the strength rating is the lower, it will be the governing value. In the event that the durability rating is the lower, the ratings to be used will be as follows:

Class 0 (0-500 hours a year) — Strength horsepower.
Class 1 (501-1000 hours a year) — Durability horsepower plus 75 per cent of the difference between the strength and durability horsepower.
Class 2 (1001-2000 hours a year) — Durability horsepower plus 50 per cent of the difference between the strength and durability horsepower.
Class 3 (2001-3000 hours a year) — Durability horsepower plus 25 per cent of the difference between the strength and durability horsepower.
Class 4 (3001-4000 hours a year) — Durability horsepower.

The required hours for a particular crane will be taken from Table 43-III for the particular motion concerned (bridge, trolley or hoist) unless otherwise specified.

G. No split gears shall be used, and overhung gears, other than the armature pinion of motors cannot be used without the approval of the purchaser.

H. In the selection of the gears and pinions for the crane based on the service required, it should be noted that the specification sheet may specify the Brinell surface hardness required. This number shall be stamped on the rim of pinions and gears to facilitate future replacement.

I. Tolerances:

1. The following tolerances apply only to gears and pinions having a ratio of diameter to face width not exceeding 8 to 1.

2. In all gears and pinions cut after heat treatment, or gears and pinions where no heat treatment is applied, the tolerances shall conform to AGMA gear tolerances and inspection standards No. 231.01, 232.01, and 233.01, which is also issued as ASA Standard B6.6-1946.

3. All spur gears and pinions cut before heat treatment shall have the following maximum tolerances. All dimensions are in inches. The outside diameter, used as the basis for determination of undersize, is the original outside diameter as turned, which must not be modified.

a. Undersize:

1. Tolerance limits from the center of gear to the outside diameter shall be:

$+0.015$ in. $\div$ diametral pitch.
-0.002 in. $\times$ pitch diameter.

(The minus tolerance, however, shall not exceed $-0.080 \times$ the working depth of the tooth).

b. Taper of Tooth:

1. The tooth surface measured at the pitch line shall be parallel with the axis of the gear within $0.0001 \times$ pitch diameter, per inch of face, and shall not exceed $0.003 \times$ the working depth of the tooth per inch of face.

2. The total taper of width of face shall not exceed $0.018 \times$ the working depth of the tooth.

4. All straight bevel gears and pinions shall conform to the tolerance limits specified above for spur gears. Determination for bevel gears is made by using the diameter of the crown circle for determination of undersize, and the cone center for determination of "taper of tooth."

5. All helical and herringbone gears and pinions shall conform to the tolerance limits specified above for spur gears. In the case of gears of these types, the taper of the tooth shall be determined from the helix angle. Determination for gearing of these types shall be considered to cover the full face in the case of single helical gears, and for half of the net total face in the case of herringbone gears.

J. Gearing shall be designed in accordance with AGMA Standard Rating — "Surface Durability of Spur Gears" — 210.01, December, 1946, and AGMA Standard Rating — "Strength of Spur Gear Teeth" — 220.01, December, 1946, or gearing shall be so designed that the following ratings (based on AGMA Standards) for durability and strength are not exceeded:

1. Allowable Durability

$$Hp = K_1 \times K_2 \times K_3 \times K_4 \times K_5$$
for 20 degree pressure angle
$$Hp = 0.75\, K_1 \times K_2 \times K_3 \times K_4 \times K_5$$
for 14½ degree pressure angle

2. Allowable Peak Strength $= \dfrac{0.5\, K_3 \times K_4 \times K_7 \times K_8}{\text{diametral pitch}}$

3. Values for K_1, K_2, K_3, K_4, K_5, K_7, K_8 will be found in Tables 36-I, 36-II, 36-III, 36-IV, 36-V, 36-VII, and 36-VIII of this section.

4. The appropriate service factor given in Table 36-VI will be applied to the Hp formulae above in computing the horsepower. Above formulae are based on a continuous contact to the tip of the pinion tooth. Where tip relief is employed, contact stress factor K_5 should be recalculated based on the actual line of action.

5. Ratings apply to enclosed gear drives or open gears, but mounting must be sufficiently rigid to reduce deflections to a minimum. Ratings are based on proper lubrication. AGMA standards limit pitch line velocity of spur gears to a maximum of 3500 feet per minute.

6. Minimum Brinell hardness of spur pinions and mating gears is to be in accordance with one of the standard combinations shown in the table for K_1.

7. The actual load and not the rating of the motor or prime mover is to be used in computing the horsepower. Where the torque varies over one revolution of the gear, the peak transmitted torque will be used. If brake torques are in excess of the maximum driving torque, the brake torque will be used in the horsepower computation. In the event that the maximum load is a continuous load, a factor of ½ will be applied to the allowable peak strength horsepower.

37. Gear Covers:

A. All gears shall be completely covered or guarded by covers, firmly and substantially attached to brackets or other parts of crane, and shall have sufficient clearance to prevent their being struck by any of the enclosed parts, and shall be oil tight.

TABLE 36-I — K_1 VALUES

Allowable durability hp values — Standard 20 degree full depth tooth, 1 in. face width — 950 rpm — 5:1 gear ratio — Service factor of 1

PDp	BHN — Pinion/Gear								
	210/180	265/225	285/245	315/270	350/300	450/350	500/500	575/575	700/630
1	1.1	1.3	1.5	1.7	2.1	2.4	3.1	3.6	4.3
2	3.8	4.9	5.5	6.3	7.4	8.9	11.8	12.8	16.5
3	....	.....	.....	.....	.....	.....	.....	.....	.....
4	12.9	16.5	18.6	21.5	25.3	30.1	38.3	43.5	53.4
5	....	.....	.....	.....	.....	.....	.....	.....	.....
6	25.0	32.1	36.2	42.0	49.2	58.8	74.7	84.8	105.0
7	....	.....	.....	.....	.....	.....	.....	.....	.....
8	38.6	49.5	55.8	64.6	76.0	90.6	115.0	131.0	161.0
10	52.7	67.5	76.0	88.1	103.7	123.5	157.0	178.0	220.0
14	74.9	95.9	108.0	125.4	147.0	176.0	223.0	253.0	312.0
16	82.0	105.0	118.5	137.0	161.0	192.0	244.0	277.0	342.0
18	85.0	109.0	122.8	142.0	167.0	199.4	253.0	288.0	354.0
18.14	85.4	109.4	123.4	143.0	168.0	201.0	255.0	289.0	358.0
20	82.4	105.5	119.0	138.0	162.0	193.4	246.0	279.0	345.0

TABLE 36-II — K_2 VALUES

Multiplication Factor for Correction of Gear Ratio

Gear ratio	Correction factor
1.0	0.60
1.5	0.718
2.0	0.80
2.5	0.855
3.0	0.90
3.5	0.932
4.0	0.96
4.5	0.982
5.0	1.00
6.0	1.03
7.0	1.05
8.0	1.068
9.0	1.08
10.0	1.09

TABLE 36-III — K_3 VALUES

Multiplication Factor for Correction of Face Widths

Face width	A	B	C
	Gearing for 1st reduction	Gearing for 2nd reduction	Gearing for 3rd reduction
1	1.00	1.35	1.51
2	2.03	2.67	2.92
3	2.95	3.94	4.22
4	3.87	5.16	5.56
5	4.76	6.35	6.70
6	5.60	7.46	7.86
7	6.38	8.52	8.93
8	7.10	9.49	9.94
10	8.51	11.3	11.9
12	9.62	12.8	13.5
15	11.1	14.8	15.6
18	12.1	16.2	17.1
20	13.5	18.1	19.1

If gearing is for first set of reduction, use values from Column A.
If gearing is for second set of reduction, use values from Column B.
If gearing is for third set of reduction, use values from Column C.

TABLE 36-IV — K_4 VALUES

Multiplication Factor for Speed Correction

PDp	Rpm								
	1750	1430	950	520	230	100	56	25	13.5
1	1.697	1.439	1.000	0.580	0.270	0.122	0.0691	0.0312	0.0171
1½	1.636	1.403	1.000	0.588	0.276	0.128	0.0721	0.0326	0.0179
2	1.585	1.386	1.000	0.597	0.287	0.130	0.0750	0.0340	0.0185
2½	1.550	1.363	1.000	0.608	0.296	0.135	0.0777	0.0356	0.0195
3	1.521	1.340	1.000	0.616	0.304	0.139	0.0805	0.0370	0.0202
3½	1.479	1.322	1.000	0.628	0.310	0.143	0.0832	0.0383	0.0210
4	1.432	1.301	1.000	0.639	0.318	0.148	0.0857	0.0396	0.0217
4½	1.380	1.276	1.000	0.642	0.321	0.152	0.0880	0.0408	0.0225
5	1.359	1.258	1.000	0.655	0.331	0.156	0.0914	0.0425	0.0233
6	1.271	1.208	1.000	0.664	0.343	0.165	0.0964	0.0448	0.0247
7	1.180	1.159	1.000	0.689	0.360	0.174	0.1021	0.0477	0.0263
8	....	1.108	1.000	0.701	0.377	0.183	0.1081	0.0505	0.0282
9	....	1.056	1.000	0.725	0.395	0.195	0.1150	0.0539	0.0300
10	....	.....	1.000	0.752	0.417	0.208	0.1231	0.0578	0.0327
12	....	.....	1.000	0.813	0.472	0.238	0.1422	0.0674	0.0376
14	....	.....	1.000	0.883	0.533	0.272	0.1641	0.0783	0.0437
16	....	.....	.....	0.982	0.620	0.321	0.1947	0.0334	0.0523
18	....	.....	.....	1.106	0.723	0.383	0.2330	0.1126	0.0632
20	....	.....	.....	1.287	0.884	0.477	0.2920	0.1413	0.0877

TABLE 36-V — K_s VALUES

Multiplication Factor for Contact Stress

Table V_A — 20 Degree full depth

Number teeth on pinion	Standard addendum teeth Gear ratio						Long addendum teeth Gear ratio	
	1:1	1.5:1	2:1	3:1	5:1	10:1	3:1	10:1
12	.....	.....	.....	.....	.....	.....	0.990	0.990
16	0.930	0.860	0.830	0.800	0.770	0.750	1.042	1.051
20	0.963	0.910	0.888	0.886	0.842	0.823	1.062	1.076
25	0.983	0.945	0.925	0.908	0.892	0.877	1.069	1.086
35	0.994	0.970	0.957	0.945	0.935	0.924	1.067	1.090
50	0.999	0.985	0.977	0.969	0.963	0.956	.....	.....
65	1.000	0.990	0.984	0.978	0.974	0.970	.....	.....

Table V_B — 20 Degree stub tooth

12	0.659	0.579	0.535	0.505	0.469	0.437	0.810	0.734
13	0.724	0.637	0.598	0.557	0.525	0.493	0.841	0.784
14	0.770	0.685	0.642	0.603	0.573	0.543	0.869	0.821
15	.....	.....	.....	.....	.....	.....	.....	.....
16	0.832	0.750	0.718	0.673	0.645	0.616	0.904	0.872
17	.....	.....	.....	.....	.....	.....	.....	.....
18	0.872	0.792	0.765	0.724	0.698	0.670	0.930	0.907
20	0.900	0.830	0.800	0.762	0.740	0.713	0.944	0.930
25	0.944	0.884	0.857	0.827	0.805	0.785	0.971	0.963
29	0.960	0.910	0.884	0.859	0.840	0.820	0.984	0.980
35	0.974	0.933	0.909	0.890	0.872	0.856	0.998	0.996
41	0.982	0.948	0.924	0.909	0.893	0.880	1.006	1.006
50	0.990	0.963	0.941	0.928	0.915	0.904	.....	.....
65	0.996	0.975	0.955	0.946	0.936	0.927	.....	.....

Table V_C — 14½ Degree full depth

	1:1 Gear Ratio Standard Add.	10:1 Gear Ratio Standard Add.	3:1 Gear Ratio Long Add.	5:1 Gear Ratio Long Add.	10:1 Gear Ratio Long Add.
12	.....	.....	.....	.....	1.108
15	.....	.....	.....	1.160	1.183
20	.....	.....	.....	1.196	1.229
24	.....	.....	1.155	1.205	1.241
31	1.000	0.975	1.160	1.204	1.244
41	1.000	1.004	1.151	1.193	1.233
50	0.998	1.018	.....	.....	.....
65	0.996	1.030	.....	.....	.....

NOTE: 20 Degree full depth — Standard addendum teeth, addendum = 1/P. Long addendum teeth, pinion addendum = 1.5/P, gear addendum = 0.5/P.
20 Degree stub tooth — Standard addendum teeth, addendum = 0.8/P. Long addendum teeth, pinion addendum = 1.2/P, gear addendum = 0.4/P.
14½ Degree full depth — Standard addendum teeth, addendum = 1/P. Long addendum teeth, pinion addendum = 1.5/P, gear addendum = 0.5/P.
P = Diametral pitch.

TABLE 36-VI — SERVICE FACTOR

Prime mover	Duration of service	Character of load on driven machine		
		Uniform	Moderate shock	Heavy shock
Electric motor.....	8-10 Hr per day	1.00	0.80	0.57
	24 Hr per day	0.80	0.67	0.50

TABLE 36-VII — K_T VALUES

Peak hp Strength Values
for
1 in. face width — 1 P — 950 rpm — Y factor of 1 — Service factor 1

PDp	BHN Pinion/Gear					
	210/180	265/225	285/245	315/270	350/300	450/350 and above
1	191.2	245.0	262.0	295.0	311.0	344.0
2	349.0	448.0	478.0	520.0	567.0	628.0
4	580.0	756.0	809.0	880.0	957.0	1062.0
6	770.0	989.0	1057.0	1149.0	1250.0	1388.0
8	922.0	1176.0	1258.0	1368.0	1488.0	1658.0
10	967.0	1240.0	1325.0	1441.0	1589.0	1738.0
12.6	992.0	1278.0	1361.0	1460.0	1610.0	1765.0
14	983.0	1262.0	1350.0	1469.0	1597.0	1771.0
16	931.0	1195.0	1279.0	1390.0	1512.0	1677.0
18	874.0	1122.0	1200.0	1306.0	1420.0	1575.0
20	765.0	980.0	1050.0	1140.0	1241.0	1377.0

TABLE 36-VIII — K_s FACTORS

Y_k Factors for Spur Gears

Number teeth (pinion)	20 Degree pressure angle — full depth				14½ Degree pressure angle — full depth				20 Degree pressure angle — stub			
	1/1 Ratio	50 Tooth gear	100 Tooth gear	150 Tooth gear	1/1 Ratio	50 Tooth gear	100 Tooth gear	150 Tooth gear	1/1 Ratio	50 Tooth gear	100 Tooth gear	150 Tooth gear
17	0.330	0.351	0.363	0.367	.....	.....	.....	.....	0.344	0.367	0.374	0.388
20	0.346	0.366	0.376	0.380	.....	.....	.....	.....	0.364	0.378	0.390	0.402
25	0.368	0.386	0.394	0.400	.....	.....	.....	.....	0.387	0.395	0.410	0.420
30	0.390	0.404	0.410	0.417	.....	.....	.....	.....	0.405	0.409	0.425	0.433
32	.....	.....	.....	.....	0.313	0.337	0.344	0.350	.....	.....	.....	.....
35	0.410	0.419	0.424	0.431	0.322	0.342	0.350	0.356	0.417	0.420	0.435	0.444
40	0.425	0.431	0.437	0.444	0.334	0.349	0.359	0.365	0.425	0.429	0.442	0.451
45	0.438	0.441	0.447	0.454	0.344	0.355	0.366	0.373	0.433	0.435	0.447	0.458
50	0.448	0.448	0.456	0.463	0.352	0.361	0.372	0.379	0.439	0.439	0.453	0.462
55	0.457	.....	0.462	0.470	0.360	0.366	0.377	0.385	0.445	.....	0.457	0.466
60	0.463	.....	0.468	0.476	0.367	0.370	0.382	0.391	0.451	.....	0.462	0.470
70	0.475	.....	0.478	0.487	0.379	0.379	0.391	0.400	0.461	.....	0.469	0.476
80	0.484	.....	0.487	0.497	0.390	.....	0.398	0.409	0.470	.....	0.475	0.482
90	0.493	.....	0.495	0.505	0.399	.....	0.403	0.416	0.478	.....	0.480	0.486
100	0.501	.....	0.501	0.512	0.408	.....	0.408	0.422	0.485	.....	0.485	0.490
125	0.520	.....	.....	0.525	0.426	.....	.....	0.432	0.498	.....	.....	0.499
150	0.536	.....	.....	0.536	0.441	.....	.....	0.441	0.506	.....	.....	0.506

Addendum = 1/P	Addendum = 1/P	Addendum = 0.8/P
Dedendum = 1.157/P	Dedendum = 1.157/P	Dedendum = 1/P
Working depth = 2/P	Working depth = 2/P	Working depth = 1.6/P
Hob edge radius = 0.24/P	Hob edge radius = 0.20/P	Hob edge radius = 0.304/P

B. Covers shall be split horizontally and fastened and arranged so that top half can be removed for inspection and repairs without disturbing bottom half.

C. Directly above the mesh line of the teeth, there shall be a hand-hole, with cover held closed by spring hinge. If specified by purchaser, a bolted cover with gaskets may be used.

D. Gear covers should preferably be of sheet steel not less than 3/16 in. thick, of welded construction, and shall be provided with lugs or other means of handling.

E. If specified on the information sheets, the housings or pedestals of the crane shall be designed to allow 15 per cent increase or decrease in the total gear ratio of each drive, in order that the speeds of the various motions of the crane may be changed in the future.

38. Brakes:

A. Hoist Brakes:

1. Each hoisting motor shall be equipped with a magnetic brake of size recommended by the brake manufacturer for the service. The brake shall be mounted on the outboard end of the motor speed pinion shaft, the end of which shall have a taper fit for the brake wheel of the same dimensions as that on the armature shaft.

2. On cranes where additional protection, or small hoisting or lowering increments are required, a second brake may be specified by the purchaser. This brake shall be a duplicate of the other brake and mounted on commutator end of the armature shaft.

B. Trolley Brakes:

1. Where specified, trolleys with anti-friction bearings shall be provided with either a mechanical drag brake or an under-sized magnetic brake. The drag brake can be installed either on the trolley motor shaft or directly on the periphery of one of the trolley track wheels. Brake will be of sufficient capacity to prevent trolley from drifting.

C. Bridge Brakes:

1. Each bridge drive shall be equipped with hydraulic brake or brakes, of sufficient size to stop crane within a distance in feet equal to ten per cent of full load speed in feet per minute, when traveling at full speed with full load. The size of brake furnished shall be the responsibility of the contractor.

2. The stroke of the bridge brake foot pedal shall not be more than 8 in., and lever shall be so designed that it will not interfere with necessary movements of operator's legs or feet while operating the crane.

3. If specified on the information sheets, all cranes with bridge drive designed for more than 300 fpm bridge speed, shall be provided with safety dynamic braking for the bridge motor which will provide automatic braking in both directions upon power failure. Such dynamic braking will be in addition to the hydraulic brakes. The use of shunt armature control should be considered to limit the top speed at light loads.

4. If specified, cranes shall be provided with electro-hydraulic brakes on the bridge drive, so arranged that brake will be set when the main disconnecting switch on the foot-walk or in the cab is opened.

D. Upon final adoption by the AISE of its Specifications for Brakes for Mill Motors, brake dimensions and ratings used shall conform to this specification.

39. Lubrication:

A. Arrangements shall be made by contractor to permit the proper lubrication of all parts requiring same, and contractor shall furnish all fittings and equipment necessary for this purpose unless otherwise specified on information sheets. Size and type of fitting will be as specified on the information sheets.

B. Each bearing, except those lubricated by oils in the gear housings, shall have an individual lubricating fitting located at an easily accessible point. Anti-friction bearings shall be provided with vents, equipped with relief fittings, to prevent air pockets. Vents shall be so located as to be visible to the operator when greasing.

C. Lubrication of all gears and pinions shall conform to AGMA Standard Specifications of Enclosed and Open Gearing No. 250.01.

D. If specified on the information sheets, a centralized lubrication system shall be used.

40. Bolts, Nuts, and Rivets:

A. Unless otherwise specified, bolts shall be "American Standard Heavy" (as approved by the latest specification of the American Standards Association), and nuts shall be "American Standard Heavy" cold pressed hexagon. Bolts shall be provided with locknuts, grip locknuts, two full size nuts, or other means to prevent their being loosened by vibration. Heads of bolts in inaccessible places shall be held from turning by recesses or projecting lugs.

B. No studs, cap screws or body bound bolts shall be used, except in locations authorized in other sections of these specifications.

C. In all structural work, such as gusset plates, brackets supporting foot-walk and bridge line shaft, bolts are not to be used. Welded or riveted construction shall be used in these locations.

Electrical Details

41. Conductors:

A. Conductors shall be mounted outside of girders and above the deck of the foot-walk and shall be of the rigid type, of low carbon steel for good conductivity.

B. Where possible, conductors shall be of single length; otherwise, sections of conductors are to be welded together with contact surface at weld ground smooth. On cranes where conductors cannot be shipped assembled, sections of bars shall be welded and ground smooth at erection, unless otherwise specified.

C. The vertical clearance between conductor contactor shoes and the adjacent conductor supports shall not be less than 1¼ in.

D. On cranes for which magnet cable reels are not specified, provision is to be made on conductor supports and collector staff for two additional bars and shoes that could be used for magnet control or other purposes. Hoist and trolley motors are to be provided with four bars for each motor, unless control design requires additional bars.

E. The main conductors for the crane bridge travel will be furnished and erected by the purchaser. Location and size of these conductors will be furnished by the purchaser.

F. Supports for conductor bars shall be spaced not more than 6 ft for flat bars, and not more than 8 ft for angles, or similar shapes.

42. Collector Shoes:

A. The main bridge collector shoes (two for positive collector and two for negative collector) and also the trolley collector shoes are to be furnished by the contractor, unless otherwise specified by purchaser. Means for easy access to these shoes for repairs shall be provided.

B. If specified on the information sheet, two collector shoes will be furnished for hoisting motion (and the magnet circuit where applicable).

C. All collector shoes are to be of type specified on information sheets.

43. Motors:

A. All motors used on cranes shall be of the totally enclosed mill type in accordance with AISE Standard No. 1, "D-C Mill Motor Standards." A design using motors without back axle is preferred to facilitate easy changing of the entire motor. Provisions shall be made by means of lugs or similar construction to line up and hold motors in correct position to eliminate the shear on the motor foot bolts.

B. The size of motors required shall be sufficient to meet duty cycle requirements, when known, and shall be based on the characteristic curves for the motor. When duty cycle requirements are not known, the motor size shall be based on the one hour mill rating of the motor and shall be calculated as follows:

1. Hoist motor

a. The hoist motor shall be so selected that its one hour rating will be not less than that given by the following formula:

$$HP = \frac{0.75WV}{33{,}000E}$$

where W = weight of the rated load on the hook plus the weight of the block and cable in lb.

V = specified hoisting speed in fpm.

0.75 = ratio of 60 minute (mill rating) hp to the 30 minute (crane rating) hp of the motor.

E = combined efficiency of gears and sheaves.

Following tabulation gives some of these values for two pairs of gears and various numbers of sheave wheels:

No. Sheaves	Efficiency, sleeve bearings	Efficiency, roller bearings
1	0.85	0.89
2	0.83	0.88
3	0.82	0.88
4	0.80	0.87
5	0.78	0.86
6	0.77	0.85
7	0.75	0.84
8	0.74	0.83
9	0.72	0.82
10	0.71	0.81

The above tabulation is based on two pairs of gears which covers most cases. However, if other combinations are used, the efficiency shall be computed by the following formulae:

$E = 0.93^n \times 0.98^m$ for sleeve bearings.

$E = 0.95^n \times 0.99^m$ for roller bearings.

where n = number of pairs of gears.

and m = number of sheaves between drum and equalizer passed over by each part of the moving rope attached to the drums.

Values of exponents are evaluated in Table 43-I.

TABLE 43-I

Exponents for Hoist Motor Formula

Power	0.93	0.95	0.98	0.99
1	0.930	0.950	0.980	0.990
2	0.865	0.902	0.960	0.980
3	0.805	0.857	0.942	0.971
4	0.748	0.814	0.922	0.962
5	0.696	0.774	0.904	0.952
6	0.647	0.735	0.886	0.942
7	0.603	0.698	0.868	0.933
8	0.560	0.664	0.850	0.924
9	0.521	0.630	0.834	0.914
10	0.484	0.598	0.816	0.904

b. In determining the gear ratio, the motor rpm, of the frame size selected, at the horsepower given by the formula:

$$Hp = \frac{WV}{33{,}000E}$$

will be used in determining the hoist gear ratio.

2. Bridge and trolley motor

a. The force required to drive the bridge or trolley consists of that necessary to overcome rolling friction, and that necessary to accelerate or decelerate the crane. The rolling friction is proportional to the total weight of the crane, and is assumed to be constant at all speeds. Unless otherwise specified on the information sheets, an overall friction factor of 15 lb per ton will be used for roller bearing cranes and 24 lb per ton for sleeve bearing cranes. Mechanical efficiencies are included in these factors.

b. The size of the bridge and trolley motor (1 hour mill rating) will not be less than that computed from the following formula:

$Hp\ (60\ min) = K_a\ WV$

where W = total weight of crane or trolley plus load in short tons.

V = specified speed in fpm.

The factor K_a includes power for both overcoming friction and accelerating the crane or trolley. Values of K_a are given in Figure 43-1. The required acceleration on the resistor (for selection of K_a factor) is as specified on the information sheets.

c. A motor selected on the basis of paragraph 43 B 2b above will have sufficient torque for the required duty cycle. However, motor heating capacity may be insufficient and must be checked. Therefore, the actual motor size will be the horsepower rating computed above multiplied by a service factor selected from Table 43-II. Data on average service for the various motions of a mill crane, as determined by a survey of the steel industry, are given in Table 43-III. These service data will be used, unless otherwise specified, to select the appropriate service or heating factor in Table 43-II.

d. The gear ratio for bridge and trolley motors will be determined as follows: *First* compute the running horsepower from the following formulae:

$Hp = 0.000455\ WV$ (Roller bearings)

$Hp = 0.000728\ WV$ (Sleeve bearings)

Second from speed curve of the motor, take speed of motor which corresponds to running horsepower.

Figure 43-1

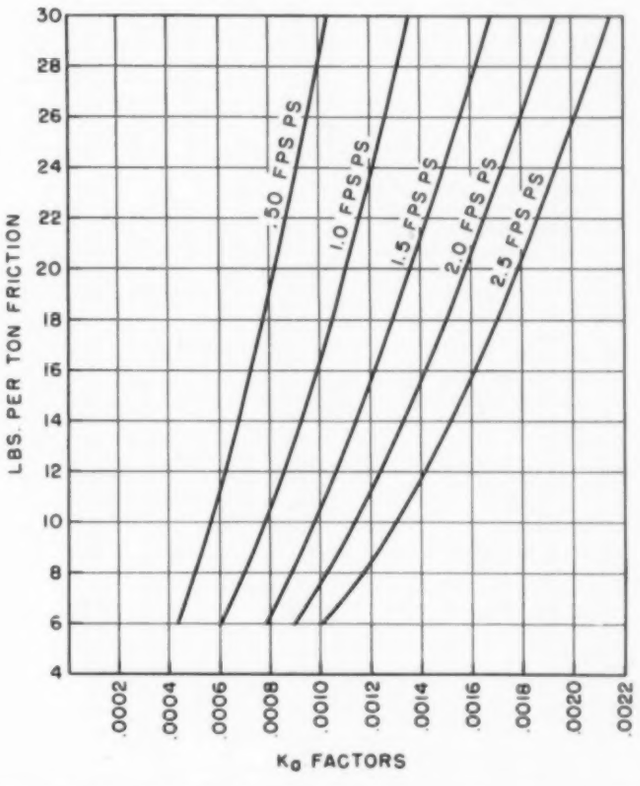


TABLE 43-II

Class	Maximum per cent time on of motion	Maximum round trips per hour	Bridge service factor		Trolley service factor
			No plugging	With plugging	
0	20	15	1.0	1.1	1.2
1	30	25	1.1	1.2	1.3
2	40	35	1.2	1.3	1.4
3	50	45	1.3	1.4	1.5
4	more than 50	more than 45	1.4	1.5	1.6

TABLE 43-III

Crane Service Data

	Crane			Bridge			Trolley			Main hoist			Auxiliary hoist		
	Average number of hours operation in one year	Normal ambient temperature during operation	High ambient temperature during operation	Average number of hours operation in one year	Per cent time on in operational hour	Number of moves per hour	Average number of hours operation in one year	Per cent time on in operational hour	Number of moves per hour	Average number of hours operation in one year	Per cent time on in operational hour	Number of lifts per hour	Average number of hours operation in one year	Per cent time on in operational hour	Number of lifts per hour
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Coke Plant and Blast Furnace Cranes:															
Drawing machine (coke pusher)	7200	80	135	3240	45	17	2088	29	9	1296	18	7	1440	20	6
Bucket handling	3240		110	1458	45	19	1458	45	25	2009	62	25	2106	65	27
Stock yard	6840			3078	47	14	3762	55	48	2941	43	38	2736	40	100
Slag handling	5400		100	1670	31	21	1836	34	30	2052	38	21	3240	60	35
Scrap yard	7200			3240	45	30	1440	20	27	4104	57	80			
Cast house	1080			648	60	32	400	37	32	616	57	75	432	40	20
Pig machine						15		90	15		90	4		5	2
Ladle house	1800			360	20	22	630	35	25	576	32	15	846	47	17
Skull cracker	720			36	5		576	80	30	648	90	30	14	2	1
Sand house (bucket)	360			324	90	21	342	95	21	54	15	21	324	90	20
Setting basin	720			360	50	30	108	15	60	180	25	60	216	30	60
Car repair shop	1440			216	15	20	288	20	35	432	30	40	288	20	20
Ore bridge	7560			756	10	10	3780	50	35	454	6	35	3024	40	35
Coke ovens (Coal bridge)	5760			1440	25	15	2880	50	78	634	11	78	2419	42	78
2. Open Hearth, Electric Furnace, Bessemer Cranes:															
Charging machines	6840	91	111	2120	31	98	3146	46	89	1847	27	80	1368	20	88
Hot metal crane (charging)	6480	118	129	2850	44	27	1426	22	32	1750	27	13	2592	40	31
Ladle	6480	101	108	2916	45	33	3110	48	23	1690	26	9	1361	21	18
Metal mixer crane	3600	90	120	648	18	12	1008	28	18	1980	55	20	1080	30	33
Electric furnace charging cranes	2880			864	30	45	864	30	60	1728	60	100			
Stock yard	6480	70	80	1940	30	76	2851	44	89	3110	48	93			
Scrap preparation					10	64		50	64		40	32			
Scrap baler crane	7560			2040	27	40	2268	30	40	3780	50	80			
Scrap shear crane	7560			4990	66	40	1275	17	40	4838	64	80			
Hot top	5400		130	1350	25	55	810	15	57	1890	35	30	2430	45	90
Bucket	5040			2420	48	52	2218	44	49	2066	41	43	1915	38	20
Slag handling	6480			1820	28	25	1944	30	8	2268	35	10			
Cinder yard	5040	70	100	2120	42	55	2621	52	80	3276	65	82	4032	80	25
Skull cracker	6480	70	80	1620	25	70	2592	40	71	3110	48	23	3564	55	37
General service	3960		100	1310	33	22	911	23	26	555	14	23	1584	40	56
3. Ingot Handling Cranes:															
Ingot handling	6840			1500	22	30	1163	17	33	3762	55	17	342	5	28
Soaking pit	3960	122	145	1660	42	42	1703	43	42	2020	51	60	832	21	50
Stripper	4680	70	113	1070	23	38	1638	35	38	2059	44	64	1123	24	31
Mold yard	6120	72	101	2570	42	44	1714	28	63	2815	46	55	612	10	20
4. Rolling Mill Cranes:															
Slab yard	6480	60	100	3629	56	26	1944	30	34	2786	43	30	778	12	16
Slab furnace charging	4680		105	1400	30	40	1640	35	45	2800	60	61	468	10	10
Plate and strip handling	6480	110	112	3694	57	27	1426	22	26	2203	34	41			
Billet mill	4320		108	1690	39	23	1166	27	23	2030	47	31			
Billet shipping	7200	100	100	935	13	10	864	12	10	1800	25	35			
Rail mill	3600		100	1440	40	10	720	20	20	1800	50	30			
Rail loading dock	3240	100		2430	75	20	1620	50	20	1620	50	20			
Rail shipping	7920			3240	41	30	4356	55	30	3722	47	80			
Hot mill	5400		115	1400	26	18	1296	24	22	1188	22	13	1782	33	15
Cold strip mill	6840	75	100	2530	37	20	1984	29	27	1505	22	26	2120	31	24
Coil storage	7920	75	120	5227	66	73	3247	41	72	3485	44	66			
Roll shop	4320	75	90	1730	40	28	1166	27	24	1037	24	19	1080	25	26
Mill service	5040	90	110	1810	36	30	1260	25	30	1663	33	19	1865	37	40
Machine shop	5040			1810	36	31	1410	28	41	1560	31	33	2020	40	30
Cooling building	5760		132	1840	32	26	2189	38	27	2822	49	35			
Inspection and conditioning	3600			1800	50	50	1080	30	45	2520	70	75	180	5	10
Pit cover	5400		100	2700	50	25				1350	25	20	1350	25	25

	Crane			Bridge			Trolley			Main hoist			Auxiliary hoist		
	Average number of hours operation in one year	Normal ambient temperature during operation	High ambient temperature during operation	Average number of hours operation in one year	Per cent time on in operational hour	Number of moves per hour	Average number of hours operation in one year	Per cent time on in operational hour	Number of moves per hour	Average number of hours operation in one year	Per cent time on in operational hour	Number of lifts per hour	Average number of hours operation in one year	Per cent time on in operational hour	Number of lifts per hour
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
5. Finishing Mill Cranes:															
Slab storage	6480	80	100	1944	30	40	1944	30	40	1944	30	20	324	5	2
Billet yard	3960			1660	42	32	475	12	32	1069	27	45			
Furnace room	4320			2592	60	30	648	15	30	1080	25	30			
Mill service	5040	80	105	1870	37	19	1411	28	23	1562	31	17	1109	22	25
Shipping	5760	70	100	2995	52	35	1382	24	36	2304	40	52			
Warehouse	5040	75	100	2320	46	31	1260	25	32	2419	48	35			
Sorting room	7200			3600	50	60	1800	25	60	2160	30	60			
Scale pit	360			126	35	25	72	20	25	324	90	25	324	90	25
Hot bed	1440			216	15	5	144	10	17	288	20	15			
Pickling	6840	80	110	2800	41	30	1710	25	39	2462	36	47			
Quenching			100		5	2		5	2		5	2			
Tin mill	6840	75	100	2530	37	36	1710	25	41	2394	35	42	684	10	20
Annealing	7200	67	116	2890	40	22	2232	31	24	2016	28	16	2808	39	25
Battery shop	5400			540	10	22	432	8	22	540	10	11			
6. Rod and Wire Mill Cranes:															
Billet yard	7800	67	87	4300	55	27	2340	30	27	2730	35	17			
Rod mill	4300	80	115	3000	70	25	1300	30	25	1700	40	20			
Rod dock	8000	60	110	6400	80	70	4800	60	70	3200	40	50			
Cleaning house	8000	90	100	4800	60	100	1600	20	60	3200	40	80			
Pot annealing	6900	87	110	3800	55	85	2400	35	65	1700	25	30	5500	80	100
Rod storage	7300	94	96	4400	60	34	2200	30	34	700	10	34			
Patenting department	2900	90	94	1900	65	32	450	15	32	580	20	32			
Bar bending and storage	8000	60	110	6400	80	100	2400	30	50	3200	40	40			
7. Tube Mill Cranes:															
Hot mill	8000	90	140	4800	60	60	1600	20	60	2640	33	30			
Finishing mill	8400	80	115	5050	60	70	1700	20	70	2800	33	35			
Galvanizing	8400	75	115	5050	60	70	1700	20	70	2800	33	35			
8. Miscellaneous Cranes:															
Forging manipulators	5400	80	115	2480	46	33	2430	45	30	1134	21	18	108	2	1
Hydraulic forging cranes	8640	80	110	3630	42	17	3197	37	40	3024	35	22			
Warehouse	3960			1700	43	16	713	18	17	990	25	16			
Gantry	5040	70	90	2020	40	34	2268	45	81	2520	50	88			
Repair	1800	80	102	504	28	15	360	20	14	378	21	12	396	22	15
Machine shop	5040	80	90	2068	41	21	1310	26	21	1008	20	12	1512	30	18
Service	1800			610	34	11	288	16	12	450	25	14			
Power house	1080	90	115	270	27	8	270	27	13	260	24	7	230	21	13
Motor room	1080		110	240	22	4	162	15	6	194	18	4	162	15	4

$$\text{Then Gear ratio} = \frac{(\text{RPM})\pi D}{12\ V}$$

where RPM = Motor rpm from curve at running horsepower.
D = Diameter of track wheel in in.
V = Specified velocity in fpm.
d = diameter of axle at journal, in.

44. Controls:

A. Magnetic control shall be used with all bridge and hoist motors, and also with all trolley motors whose mill rating is 15 hp and over. Trolley motors whose mill rating is below 15 hp shall be equipped with either magnetic or manual control as specified on the information sheets.

B. Magnetic control shall be in accordance with the following:

1. Control shall conform to the NEMA Industrial Control Standards for overhead traveling cranes, Section 1C-14, except as modified by these specifications.

2. Controls shall be of the full magnetic type.

3. Panels shall be Monson slate of ample thickness, mounted on angle supports with bottom of lower panel not less than 6 in. from the floor, unless otherwise specified. If Monson slate is not used, approval by purchaser of substitute material must be obtained.

4. Dynamic braking contactors shall be spring closed.

5. Resistors shall be of the type specified on information sheets and mounted in standard mill type boxes. The resistors shall be of NEMA classification numbers as specified on the information sheets. Resistors shall be based on load computation to give specified acceleration and not on motor size which may be set by thermal requirements. In

ordering control, crane manufacturer must notify control manufacturer of computed horsepower without service factors as computed by sections 43B1a, and 43B2b.

C. If enclosures are required for control panels, the type of enclosure shall be in accordance with the classifications as listed under Section 1C-2-128 of the NEMA Industrial Control Standards and as specified on the information sheets.

45. Hoist Limit Switch:

A. Each hoist motor shall be equipped with a standard dynamic braking limit stop, connected directly in the motor circuit, to prevent overtravel in hoisting. The limit stop shall have a back-out circuit for lowering hook from hoist master controller. Resistor shall be of the unit type with non-breakable corrosion resisting elements mounted in a dust tight box. The limit stop shall be located so as to be easily accessible for inspection, and, if possible, so it will be operated by the hook block, or load beam in such manner that no sheave wheels are necessary. Limit switches must reset properly and must be designed to prevent grounds.

B. An arrangement using a free swinging weighted beam, hinged at one end and having the other end attached to the limit switch operating cable shall be used to operate the limit switch. The trip bar shall be so designed that the cables cannot jump out around the end of the trip bar thus permitting the hook to raise outside the trip bar. The trip bar shall also be so designed that no movement of the hoist and trolley can enable the trip bar to be jammed against any part of the crane structure.

C. If specified on the information sheets, a weight, directly connected with the limit switch and guided by suitable guides so that twisting cannot occur, which acts on the idler cables shall be used. Cable guides should preferably have replaceable maple or bakelite guide blocks to prevent wear on the cable.

D. The actuating mechanism of the limit switch must be located so that it will trip the limit switch, under all conditions of hoist load and hoist speed, in sufficient time to prevent contact of upper and lower blocks.

E. If sheaves are used in connection with the hoist limit stop, the pitch diameter shall not be less than 18 times the rope diameter. Cables should be guided through a hole on both ends of the sheave.

46. Disconnecting Switches:

A. Each crane shall be provided with a main disconnecting switch of the unfused enclosed type, with provisions made for locking in the open position with three safety locks, and of sufficient size to meet the National Board of Fire Underwriter's requirements. This switch is to be located on the foot-walk at a point as near as possible to the main collectors. Where switches of 600 amp capacity or greater are required, a two-pole circuit breaker or a magnetic disconnect should be used.

B. A second switch or circuit breaker or means for operating the safety switch on the foot-walk shall be provided in the cab, as specified on the information sheets.

C. The following fused double-pole safety switches or "no fuse" air circuit breakers, all mounted on a small panel in the cab, shall be provided.

1. One for crane lights.
2. One for electric heater and ventilating unit.
3. One for outlet box circuit.
4. One for signal lights.
5. One for magnet control circuit if magnet cable reel is specified. (If magnet cable reel is not specified, panel shall be arranged for future mounting of safety switch).
6. One each for special devices, when applicable, such as sanders, motor operated buckets, turning devices, etc.

D. The main contactor with overload and no voltage relays for the trolley motor shall also be mounted on this panel, if manual control is used.

47. Wiring:

A. Until adoption by the AISE of its Crane Wiring Specifications, wiring shall conform to the following specification:

1. All wire shall be flexible stranded, as per ASTM specification B8-46, Class C, and IPCEA Practice and, except where subject to heat, shall be RH, 75C, 600 volt, moisture resisting rubber insulation, with neoprene covering. Where subject to heat from resistors, etc., the wire shall be covered with 600 volt AVA, 110C, insulation. Wires shall be installed in rigid metal conduits which shall be continuous to switch boxes, junction boxes or motor terminals. Flexible steel conduit shall not be used, except where desirable to make connections subject to vibration, and where specially approved by purchaser. All wiring shall be in accordance with the regulations of the National Board of Fire Underwriters and the regulations of the state and city where the crane is located.

B. All conduit shall be rigidly attached to the crane to prevent vibration, and shall have suitable bushings at all terminals.

C. Each motor shall be wired independently in separate conduits without common returns.

D. The following standard method of wiring should be used:

1. From main collector shoes, the wiring will extend to the two-pole safety switch or circuit breaker mounted on foot-walk.
2. When a second disconnect is used in the cab, wiring will extend to the main switch or circuit breaker in cab.
3. From this switch or circuit breaker, branch circuits will extend to control panels for hoist, bridge, and trolley motions and to the small panel mounting the switches for light, heater, etc. Magnet circuit switch will be located between the disconnecting means on the foot-walk and that in the cab.

E. Three outlets, of type approved by the purchaser, for plug receptacles are to be furnished on each crane; one on each walk-way near middle of span and one in cab. This circuit will be connected between the main disconnect switch on the foot-walk and the main conductors.

48. Magnet Cable Reel:

A. On cranes where magnet cable reel, or space for mounting a reel is specified, it must be so located that magnet cable will not foul hoisting cable and, if possible, avoid the use of sheaves or guide rollers for the magnet cable.

B. If the cable reel is of the type driven by gears from hoist shafting, or from extension of the drum shaft, the surface speed of the reel shall be the same as the hook speed, and a loop shall be provided in magnet cable to allow for slack. If specified, this type of reel shall be provided with a clutch for disconnecting when magnet is not in use.

C. Weather protection shall be provided for magnet cable collector rings on cranes for outdoor service.

49. Lighting:

A. All crane cabs shall be provided with adequate lighting. Where magnetic control panels are installed in the cab, lighting is to be provided in that section of the cab. Such lighting will have a separate control switch on a circuit connected between the main disconnect switch on the foot-walk and the one in the cab.

B. On the bridge structure of each crane, there shall be provided lighting fixtures, as specified on the information sheets. Lighting fixtures are to be mounted on shock absorbers, and so installed that they can be serviced from bridge foot-walks.

50. Signal Lights:

A. Each crane is to be equipped with signal lights; with number, location, color and connections as specified on the informaton sheets.

Appendix

The following notes in the appendix are given to amplify some of the design data and to give background for several of the specification clauses. Much of the girder data is the result of a research investigation carried out at Lehigh University from 1939-1941. The complete papers for this work are published in the Proceedings of the Association of Iron and Steel Engineers, 1941, "Report of Crane Girder Tests," I. E. Madsen, pp 531-577.

The numbers on the following notes refer to the appropriate specification clauses:

17-A-2

The jerk impact measured in the crane tests varied from 9-33 per cent. Theoretically the jerk impact should be $I = \frac{v^2}{57{,}600}\left(\frac{W}{0.0020l + d}\right)$ where v is the hoist speed in fpm, l is the distance between the drum and hook, and d is the deflection of the crane. This formula assumes 20,000 psi stress in the hoist rope but does not take into account any slip of the cable on the drums and sheaves which is hard to evaluate. These latter factors would reduce the impact, and also make an exact analysis impossible.

For the laboratory crane the above formula would give 17 per cent impact, and the specification clause would give 15 per cent, but specification minimum of 20 per cent would govern.

Impact measured on a skullcracker was 25 per cent of the weight of the magnet and ball. This is less than the specification would require. However, the high speed of the hoist on this type of crane causes a severe constant vibration which will cause wear and tend to loosen the crane. For this reason, the impact factor on this type of crane is kept higher than the value called for by the actual impact.

Cranes with bad runway joints (joints spread or uneven) have large impact stresses. Since the dead weight of the crane and trolley also contribute to the impact stresses, the total amount of impact due to this cause may be very large. The bad joint impact tests in the research investigation were made by running the laboratory crane over wedges under both ends of one bridge girder, thus simulating a bad joint at each end. The drop of the crane was 9/16 in., and the impacts measured when the bridge dropped through this amount were 31 per cent and 51 per cent of the live load, dead load and trolley bending moments. The lower value occurred when the load was hung just off the floor and the higher value occurred when the load was raised thus eliminating give in the rope.

When cranes are designed for runway locations where there are bad joints, the joints should either be repaired or the crane should be designed for bad joint impact. It would in general be much more economical to repair the rail joints. If the drop of the laboratory crane had been less than 9/16 in., the impact would have been less; and if the drop had been greater, the impact on the laboratory crane would have been greater.

17-A-3

End fixity was found to be present in the lateral load tests. Since such fixity reduces the lateral stresses appreciably, it may be economical to take such fixity into account. However, slip in the end connection will reduce fixity so markedly, that it is necessary to make sure that no slip occurs in the connection.

The tests made in the fabricating shops showed that the whole box girder section acted to resist the lateral loads. The mill tests showed that the maximum lateral force was about 20 per cent of the load on the braked wheels.

17-A-4

Torsional moments are similar to shears in a beam. In addition, the moment arm of the lateral forces acting on a girder will vary if the girder depth is non-uniform.

The formulae, by which the torsional shear stresses are computed, are theoretically correct for box girders. These formulae were checked by the test program.

The angle of a twist in radians per unit length is given by $\theta = \frac{M}{GJ}$

M = twisting moment in inch pounds.

G = shear modulus = 11,500,000 psi for steel.

J is analogous to the polar moment of inertia and for a box section:

$$J = \frac{4A^2}{\Sigma \frac{S}{T}}$$

where S and T are the length and thickness of each side.

For welded girders, the above formulae give results which are very close to measured values. For riveted girders, J must be multiplied by a factor of one-third to allow for the slip which occurs between the rivet and plate. In a riveted box, the length of the sides used in computing J are the distances between the rivets in the plane of the cross-section, since the twist is a function of the amount of material stressed, or the length of the stress path. ("Torsional Properties of Fabricated I-Beam and Box Sections," I. E. Madsen, Proceedings of the Association of Iron and Steel Engineers, 1941.)

17-C

Where cranes operate over very bad runway joints, it may be advisable to design the girders for a third stress combination. This combination should take into account the stress condition which occurs when the operator is decelerating while going over a bad runway joint. Since it is unlikely that the crane operator would be using maximum braking force while carrying maximum load, the lateral forces could be arbitrarily reduced by a factor of one-half. The resultant stress combination for which the crane would be designed in such a case would be the sum of the stresses due to the dead load, weight of trolley, lifted load, bad runway impact, and one-half of the lateral forces.

17-F

In box girders, the end connection is probably the only important member subject to reversal of stress. If end fixity is to be counted on in design, this connection must be designed so that no end slip will occur.

17-G-4

Since the whole section of a box girder resists the lateral loads, the lateral rigidity of a girder is then primarily a function of the distance between the web plates, rather than the width of the cover plate. This is due to the fact that most of the lateral moment of inertia of a box comes from the web plates. In addition, the torsional rigidity of a box also increases with the distance between the web plates. Therefore it seems more logical to use the ratio of the girder length to the distance between the webs as the slenderness ratio of the girder rather than the length-width ratio of the cover plate.

The values given in the specifications are conservative. The riveted girders are allowed a slightly higher ratio than the welded girders to allow for the extra stiffening effect caused by the flange angles and cover plates of riveted girders.

17-G-5

The girder tests showed that for normal proportions, there is no necessity to reduce the compressive stress below the allowable tension stress. A slight reduction has been made in the allowable compressive stresses to allow for the bending stresses in the cover plate directly under the wheel. There is no necessity to use the formula except for girders of unusual proportions. This formula is based on a safety factor of four.

17-G-12

This formula is based on the test results, and a factor has been added so that a higher H/T ratio may be used when the girder is not stressed up to its full allowable stress. The factor K has also been added to take into account the variation in the allowable H/T ratio when the web is not stressed equally in tension and compression. This factor is based on the theoretically correct constants, and expresses an equation for the constant which holds in the limits specified. The safety factor used in this formula is 1.83 or the ratio of 33,000 to 18,000 psi.

17-G-13

In order to take advantage of the higher unit stresses, it will be found economical to use longitudinal web stiffeners in many cranes rather than to use a thicker web plate. This is particularly true in alloy steel girders where the use of such stiffeners will result in very appreciable weight savings. Tables are given in the specification giving the required sizes of such stiffeners. These tables are computed on the basis that the web is stressed equally in tension and compression. If the tension is greater than the compression, the values in the table are conservative.

The stiffener values are also computed on the assumption that the vertical stiffeners are spaced at distances equal to the clear depth of the web. If the vertical stiffeners are spaced closer than this distance, the tabulated values are conservative, and if the vertical stiffeners are spaced further than this, the stiffeners should be slightly larger.

17-G-20 and 17-G-21

These specification requirements have been written so that they will also apply safely to the higher unit stresses allowed in alloy steel girders.

17-G-23

The location of horizontal stiffeners is not a constant value. The variation is slight, however, and since the specification requirement for such stiffeners is conservative, the slight variation from the theoretical position, which may occur in some cases, will have little effect.

17-G-25

This formula is empirical and gives conservative values. It is based on a large number of values computed from a more exact formula proposed by E. Chwalla and A. Novak.

17-G-30

This clause for maximum deflection is inserted to keep the deflection of the crane within such limits as will prevent the trolley from creeping. These limits will vary appreciably for roller bearing and sleeve-bearing trolleys.

The tendency for the trolley to creep would depend on the slope of the girder under the trolley. The specification clause should be based on the slope instead of the deflection. The camber which occurs in the crane would modify these factors appreciably, and proper

camber in the crane can keep the slope within such limits that there may be very little tendency for the trolley to creep even though the deflection is appreciable.

Since the dead load deflection of the girder can be neutralized by appropriate camber, it should not be considered in computing the allowable deflection. Care should also be taken that more than the specified camber is not put in a bridge girder. This is demonstrated by the fact that most of the trouble with creep in roller bearing trolleys seems to occur when the crane is light with the trolley at the quarter point. The direction of the creep in these cases is away from the span center. The maximum slope which this specification requirement would allow is 0.0015 which occurs at a distance from the end equal to one-fifth the span length, provided that the crane was cambered only for the dead load. Proper live load camber would reduce this slope. Unless the overall friction factor of the trolley is less than 3.00 pounds per ton, there should be no tendency for creep in the trolley due to this factor alone.

Creep may occur rather readily if this slope effect is added to other factors such as hook swing and runways which are out of level. However, when such other factors are present, they are likely to be the dominating factors causing trolley creep, and creep would occur even if there was no deflection in the crane.

17-G-33

This requirement is empirical and will give a rail section which would be strong enough to carry the wheel load if the flange plate were not there. Actually the flange plate may often take most of the wheel load as a beam between the two webs, and the function of the rail in such a case is to merely distribute the load. The actual load taken by each could be computed by equating the deflections of the rail and plate at the same point. Care must be taken that the crane rail and plate are both stiff enough so that excessive dishing of the plate does not occur.

34-B

The bearings listed in the bearing table are those recommended by the manufacturer for the specific application given by the table. In selecting the bearing for the crane, a bearing is selected which will give a minimum of ten years life. This life will be determined by going to Table 43-III, which gives average service for cranes, and selecting for the particular crane involved, the number of hours which either the bridge or trolley operates in a year. The number of hours which this particular motion operates in a year multiplied by 10 gives the total number hours life for which the bearing must be designed. For example, if the application is for bridge motion on a slab yard crane, we note from Table 43-III that such a bridge operates 3629 hours a year on the average. This figure is multiplied by 10 and the required bearing life is 36,290 hr. If the purchaser of the crane had specified a Timken bearing, and the box load was 40,000 lb, and the speed was 80 rpm, the designer would go to Table 34-IX, and a class 4 bearing which has a 40,000 hour B10 life would be selected. In this particular case it would be bearing number 99575-99100. The tables were made up on the following assumption:

1. Bearing selection is based on 75 per cent of the maximum load on the bearing. This is done because in most applications maximum load on the crane with the trolley in the worst position occurs only a small percentage of the time.
2. Bearing selection is based on the highest rpm in the range. It should be noted that for each class of bearings there are three columns. The first is for 1-30 rpm, the second, 31-60 rpm, and the third is for 61-100 rpm. This assumption is on the safe side.
3. For the tables which have a uniform bore line, the bore will be the same for all service classifications of cranes for a particular box load. This uniform line will not necessarily give the most economical bearing but is used where a particular plant wishes to standardize on bearing sizes and reduce inventory, even though on specific applications the bearing may be larger and therefore more expensive than is actually required for the services involved.

36

The gearing formulae are based on the latest standards of the AGMA. The procedure used in these specifications has been to compute the allowable horsepower for a standard 20 degree full depth tooth with a 1 in. face width, running at 950 rpm, in a gear ratio of 5 to 1, and with a service factor of 1. Then this horsepower is modified by factors for other conditions. The K_2 factor is a correction to take into account other gear ratios; the K_3 factor corrects for changes in face widths; the K_4 factor corrects for speeds other than 950 rpm; and K_5 values are not included in the original horsepower computation, and these values must be applied to the computation as a contact stress factor.

The durability equations are based on the endurance limit in compression for the steel at the contact point between the gear and the pinion. The stress is the computed maximum stress as determined by elasticity equations. The Brinell hardness is used as a measure of the endurance limit. In the strength calculations the allowable stress is ½ the endurance limit in tension for peak loads. The endurance stress is in turn roughly ½ the ultimate tensile strength. Thus there is a ratio of four between the tensile strength and the maximum tensile stress at the peak load, and a factor of eight between the ultimate maximum tensile strength for continuous loads. This is not, however, the same as the factor of safety, as the Y factor which has been computed for the gears takes into account the maximum stress concentration and the gears are so designed that this peak stress concentration figure is not exceeded.

The following is a sample computation for checking a pair of gears.

Given the first reduction of a set of gears, tooth form is 20 degree full depth; the face width is 2½ in.; the pitch diameter of the pinion is 3¼ in., rpm is 520; Brinell hardness of pinion is 285 and that of the gear is 245; the pinion has 26 teeth; and the gear ratio is 6:1. Load transmitted is a fluctuating load.

Durability $Hp = K_1 \times K_2 \times K_3 \times K_4 \times K_5$

From Table 36-I $K_1 = 13.7$ (By interpolation)
From Table 36-II $K_2 = 1.03$
From Table 36-III $K_3 = 2.48$ (By interpolation)

From Table 36-IV $K_4 = 0.622$ (By interpolation)
From Table 36-V $K_8 = 0.893$ (By interpolation)
$Hp = (13.7)\ (1.03)\ (2.48)\ (0.622)\ (0.893) = 19.5$
$Hp = 19.5$ (Durability)

$$\text{Peak Hp (Strength)} = \frac{(0.5)\ K_3 \times K_4 \times K_7 \times K_8}{\text{diametral pitch}}$$

From Table 36-III $K_3 = 2.48$
From Table 36-IV $K_4 = 0.622$
From Table 36-VII $K_7 = 685$
From Table 36-VIII $K_8 = 0.400$
Diametral pitch $= 26/3.25 = 8$

$$\text{Peak Hp} = \frac{(0.5)\ (2.48)\ (0.622)\ (685)\ (0.400)}{8}$$

Peak Hp $= 26.4$

Hence, wear is the deciding factor in setting the rating of the gear, and in the example, the load on this pair of gears should not exceed 19.5 hp. In the event the peak load had been a uniform load, the peak strength equation would have had a factor of ½, the peak horsepower would have been 13.2, and strength would have been the governing factor. In the event, that the gearing is not in the ranges or types covered by the tables under paragraph 36, the appropriate specifications of the AGMA should be used.

For cases where service may not be severe, as for example on a gear reduction which operates between 1000-2000 hours a year, a higher allowable horsepower could be permitted. For example, the bridge motion of bucket handling crane in a coke plant from Table 43-III operates on an average of 1458 hours a year. From paragraph 36F, the allowable horsepower on a Class 2 crane which operates between 1000-2000 hours a year, is the durability horsepower plus 50 per cent of the difference between strength and durability horsepower. Therefore, the allowable horsepower will be

$$\begin{aligned} &19.5 + 0.50\ (26.4 - 19.5) \\ &= 19.5 + 0.50\ (6.9) \\ &= 19.5 + 3.5 \\ &= 23 \text{ hp} \end{aligned}$$

This section may be used to give a somewhat smaller or more economical gear where the service is not severe.

The revised gear specifications do not rule out the materials which were accepted in the previous crane specifications, and the A_1, A_2, B_1, and B_2 materials all meet the requirements. The method for determining allowable loads is changed from the previous specification, being now based on AGMA design procedure. The new specifications, however, permit the use of a much wider choice of materials.

43-B

Horsepowers are based on mill rating, and formula applies to series, mill type motors. Factors are for average values from characteristic curves of such motors.

In order to apply a motor correctly, a clear understanding of the characteristic curves is necessary. Knowledge of a name plate rating gives only a single point on the hp curve with a corresponding point on the speed curve, and this is not sufficient to correctly apply the motor. Data given by the characteristic curves will, however, enable one to not only intelligently apply the motor but also to predict its performance. The sixty minute rating of the motor merely states that one can run the motor for sixty minutes without exceeding its temperature rise. For example, in the case of the 610 motor, this motor can be run for sixty minutes at 50 hp, and the temperature will not increase more than 75 C from an assumed ambient temperature. Similarly, for this motor the thirty minute rating states that it can run at a constant load of 65 hp for 30 minutes without increasing the temperature more than 75 C. In either case, at the end of sixty or thirty minutes the motor should be stopped if permanent damage is not to occur. On the other hand, the same characteristic curves will give information as to how long the motor can run indefinitely at various horsepowers. The percentage time on curve states that the 610 motor can be run 23 per cent of the time at 50 hp indefinitely without exceeding the allowable temperature rise, provided that the load cycles are of not more than five minutes duration. Likewise the percentage time on curve states that the motor can be run at 65 hp for 14 per cent of the time indefinitely, provided that the cycles are less than five minutes long. Thus there are an infinite number of motor ratings which could be put on a name plate. Crane service usually provides a varied and intermittent load on the motors. Exact duty cycles are usually unknown. The so-called crane rating was used as a convenient yardstick, which on the average, gave a motor which would do a satisfactory job. In the present specification, motor selection has been tied in more closely with the overall characteristic curves of the motor, which fortunately in the case of series mill motors are similar throughout the various motor sizes.

The acceleration term has not previously been used in the determination of the motor size, and is being introduced to emphasize the importance of this factor, which often may require from 3-6 times more horsepower than that required to keep the bridge or trolley rolling at top speed. Maximum acceleration occurs while the motor is on the resistor and fortunately does not correspond to top speed. As long as the motion is on the resistor, the acceleration is relatively constant, and when the motion goes off the resistor, the acceleration becomes less and at top speed is, of course, zero.

In order to set requirements, an acceleration of about 0.5 ft per sec per sec is slow, from 0.5-1.5 ft per sec per sec is medium, and from 1.5-2.5 ft per sec per sec is fast. Anything over that will probably cause the wheels to slip. If the resistors are not computed for the current in the motor which corresponds to the horsepower or torque while motor is on resistor, the acceleration may be greater than that specified, and motor will overheat more rapidly. Formulae for motor is based on assumption that motor torque on resistor is 200 per cent 1 hr rated torque. However, selecting next larger size motor than that given by formula and use of service factor, reduces ratio of torque on resistor to rated torque to less than two.

Speaking in average terms, the speed at the point when the resistor cuts out will normally be between ½ and ¾ the top speed. If this point is taken as ⅔, and the acceleration is assumed to decrease linearly after the resistor is cut out, it can be shown that the time to get up to top speed while off the resistor is equal to the time on the resistor, therefore, the overall accelera-

tion rate will be ¾ the acceleration on the resistor. As an example, if the duty cycle requires that the bridge reach a speed of 300 fpm in 10 seconds, this is equal to an overall acceleration of

$$t = \frac{300}{(60)\ (10)} = 0.5 \text{ ft per sec per sec}$$

The acceleration while on the resistor must then be about (4/3) (0.5) = 0.667 ft per sec per sec.

As an example of motor selection, let us assume that the bridge in the previous example is a mill service crane in a rolling mill. The total weight of the crane plus load is 83 tons, and the load weight is 30 tons. Plugging is not normally used to stop the crane. Bearings are anti-friction.

$$Hp\ (\text{Min } 60 \text{ min}) = K_a\ WV$$

K_a from Figure 43-I (15 lb per ton rolling friction) equals 0.0008

$$Hp = 0.0008\ (83)\ (300)$$
$$Hp = 20.0 \text{ (mill rating)}$$

This is the minimum horsepower which will move the crane at required speed and specified pick-up or acceleration. However, the motor may not have the required heating capacity to handle the required duty. For this reason, an appropriate service factor must be applied. From Table 43-III, the bridge of a mill service crane in a rolling mill is on 36 per cent of the time and makes 30 moves in an hour. This makes it a Class 2 crane and a factor of 1.2 is needed. See Table 43-II.

Mill rating of motor must therefore be at least 20.0 × 1.2 = 24 hp, and require l motor is a No. 606 with a mill rating of 25 hp.

To determine the gear ratio, first compute the running horsepower at the balancing speed.

$$Hp = 0.000455\ WV$$
$$= 0.000455\ (83)\ (300)$$
$$Hp = 11.3$$

From characteristic curve of motor, the speed at 11.3 hp = 700 rpm.

$$\text{then gear ratio} = \frac{(Rpm)\pi D}{12V}$$

$$= \frac{(700)\pi(24)}{12\ (300)} \text{ (wheel diameter assumed)}$$

$$\text{Gear ratio} = 14.6$$

The general formula for computing the horsepower, at any time during the cycle, on a bridge or trolley motor is

$$Hp = \frac{2000\ WV}{33000\ E}\left(\frac{T}{2000} + \frac{a}{32}\right)$$

W = weight of crane plus load in tons for bridge motor computations, and weight of trolley plus load for trolley motor computations
V = velocity in feet per minute
T = draw bar pull in lb per ton
a = acceleration in feet per second per secon l
E = Efficiency

When the acceleration is zero the general formula for computing the horsepower reduces to $Hp = \frac{WVT}{33000E}$

In the case of anti-friction bearings, the frictional factor of 15 lb per ton includes the efficiency, and substituting in the above, the formula reduces to

$$Hp = \frac{15WV}{33000} = 0.000455WV.$$

In the case of sleeve bearing cranes, a friction factor of 24 lb per ton including efficiency will be used. This figure is based on a ratio of track wheel diameter to journal diameter of 4:1 and a friction coefficient of 0.048. In the event that it is known that the friction factor is appreciably different from this figure (including efficiency), and in the event the ratio of the track wheel diameter to the diameter of the journal axle should be appreciably different from four, the friction factor should be computed from the following equation:

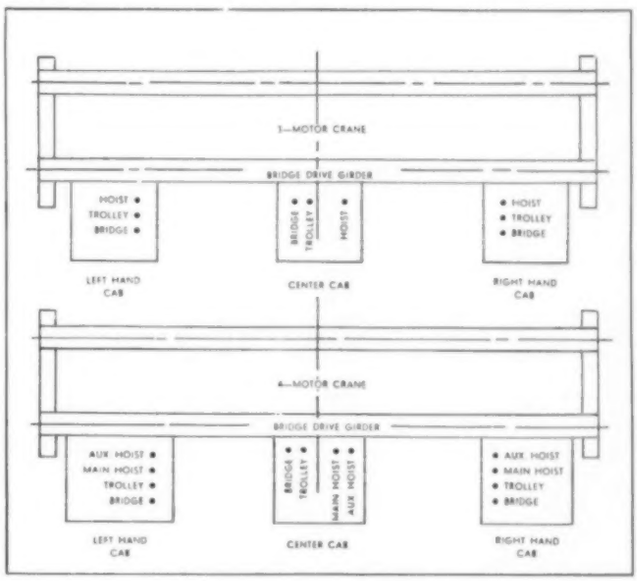
$$\text{Friction factor (sleeve bearings)} = \frac{0.043}{0.9}\left(\frac{d}{D}\right)(2000) \text{ lb per ton}$$

Wherever possible, motors should be selected on *actual duty cycle* basis. All other methods are approximations and estimates which result in average factors. Proper gearing and resistor selection for required duty must be made to avoid overheating.

44

A standard for controller handle positions is extremely desirable from a crane operator's standpoint. Such standardized positions may also prevent accidents in cases where an operator gets on a crane with which he is unfamiliar. However, the crane committee could not agree on such standardization because of existing designs, although they were fully in accord that it would be a desirable procedure. Figure 44-1 of this

Figure 44-1



appendix shows what is recommended by the Electric Overhead Crane Institute. These sketches show standard arrangement of controllers in the operator's cab for three and four motor cranes, and relative sequence of the controllers with relation to the crane hook. It does not indicate the exact location of controllers. It is suggested that this layout be used as standard wherever existing conditions permit.

44-B-5

Resistors should be based on the actual load on the crane while the crane is accelerated. Such information should be furnished to the control manufacturer by the crane manufacturer. NEMA Standards for Industrial Control, No. 45-97, September 1945 states in their resistor application table, IC4-30, that resistors for steel mill cranes shall be as follows:

Crane — Ladle-Bridge-Trolley-

Hoists ..... 153—163
Roller Bearings ..... 152—162
Sleeve Bearings ..... 153—163

These classifications are those which experience has shown is correct for the average installation, although there may be exceptions. The table applies to resistors composed of cast grids. It is also applicable to unbreakable resistors provided that the time on period does not exceed the values shown in standard IC4-10. This section states that a class 153 resistor has a duty cycle of 15 seconds out of each 60 seconds with about 70 per cent of full load current on the first point. A class 163 resistor is on 15 seconds out of each 45 seconds and has about 70 per cent full load current on the first point. A class 152 resistor is on 15 seconds out of each 60 seconds and has about 50 per cent of full load current on the first point, and a class 162 resistor is on 15 seconds out of each 45 seconds and has about 50 per cent of full load current on the first point. Where the application or duty cycle differs appreciably from that above, the designer should refer to the NEMA standard for the particular application involved.

47-A

The crane wiring committee of the Association of Iron and Steel Engineers has been working on a specification for conductor or cable size for overhead traveling cranes. This program was initiated with the publication by the National Fire Protection Association of the National Electric Code in 1947, which gave short time wire ratings. These ratings varied appreciably from those used in present practice, and as a result it was decided to review the subject to determine what would be both satisfactory and economical. One of the reasons for this difficulty is that wire ratings and capacities do not vary in the same proportions as motor ratings and capacity. Because of this difference, the wire rating cannot be selected on the basis of a motor rating, and the actual service must be taken into account. Although the work of the committee has not been entirely completed, it is now far enough along so that some of the recommendations, which is believed will be incorporated in the final report, are available. Table 47-I shows wire sizes of the proposed standard and may be used as a guide until the final specification has been approved officially by the AISE. In order to determine whether a crane is heavy duty or average duty service, look at Table 43-III, which gives average service of cranes, and if the crane is operated over 4300 hours a year, or the particular motion is on more than 40 per cent in an operational hour, it may be considered as being subjected to heavy duty service. If the crane is operated under 4300 hours a year, and the particular motion is on less than 40 per cent in an operational hour, it may be considered as being subjected to average duty service. If the maximum crane temperature during operation is under 75C(167F), RH cable with moisture resistant 75C insulation with neoprene covering and standard stranding will be used. If the maximum crane temperature during operation is over 75C(167F), AVA cable having asbestos varnished cambric asbestos 110C insulation with moisture resistant impregnation and standard stranding will be used.

TABLE 47-I

AISE Crane Wiring Committee Proposed Standard

Conductor Sizes for Series Mill Type Motors for Overhead Traveling Cranes

Motor frame					Heavy duty service						Average duty service					
					1	2	3	4	5	6	1	2	3	4	5	6
AISE (1949)	AISE (1940)	General Electric	Westing-house	Crocker-Wheeler	Hp ½ hour	Amp ½ hour	Condr size per leg	Con-duit size	Amp Type RH 75 C	Amp Type AVA 110 C	Hp 1 hour	Amp 1 hour	Condr size per leg	Con-duit size	Amp Type RH 75 C	Amp Type AVA 110 C
2	2	MD-402	MC-21	SW-5	6½	29	8	1¼	60	67	5	21	8	1¼	60	67
602	3	MD-403	MC-31	SW-7½	10	44	8	1¼	60	67	7½	31	8	1¼	60	67
603	4	MD-404	MC-41	SW-10	13½	57	8	1¼	60	67	10	40	8	1¼	60	67
604	6	MD-406	MC-61	SW-15	19	77	6	1¼	86	82	15	57	6	1¼	86	82
606	8	MD-408	MC-81	SW-25	33	126	2	1½	150	153	25	95	4	1½	110	117
608	10	MD-410	MC-101	SW-35	45	175	1	2	175	190	35	132	2	1½	150	153
610	12	MD-412	MC-121	SW-50	65	245	2/0	2½	245	291	50	185	1/0	2	205	243
612	14	MD-414	MC-141	SW-75	100	368	4/0	2½	360	423	75	272	3/0	2½	300	360
614	16	MD-416	MC-161	SW-100	135	500	300	3	485	593	100	360	250	3	420	513
616	18	MD-418	MC-181	SW-150	200	740	500	3½(4)*	750	908	150	540	350	3½(4)	560	768
							500	3(2)	750	908			350	2½(2)	560	768
							2-250	3	840	1026			2-3/0	2½	600	720
618	....	MD-420	.....	.....	265	960	2-300	3	970	1186	200	730	500	3½(4)	750	908
													500	3(2)		
													2-250	3	840	1026

*Number in parentheses indicates number of conductors in conduit.

AISE CRANE SPECIFICATIONS

PURCHASER'S INFORMATION SHEETS

.....Company

.....Works

Located at.....

Specification No..... Dated.....

For

.....TON ELECTRIC OVERHEAD TRAVELING CRANE

(This information to be furnished bidder by purchaser)

The following specific information, together with the AISE Specifications for Electric Overhead Traveling Cranes, dated....., shall form the complete specifications of number as noted above.

Contractor shall furnish.....

.....

.....

as covered by these specifications.

Crane to be delivered F.O.B.....

Complete wiring of crane, including furnishing of switches, panels, lighting fixtures, etc., shall be done by .....

All motors, controls for motors, hoist limit switches and magnetic brakes shall be furnished by..... (If furnished by purchaser, they will be delivered F.O.B. contractor's plant for erection by the contractor on the crane.)

Number of sets of prints, etc., to be furnished:

1. Specifications.....
2. Bills of material.....
3. Are prints or tracings required?.....
4. General arrangements, and
   - (a) Details of such parts as are subject to wear and will require replacement.....
   - (b) All details.....

Cranes covered by these specifications will be used for.....

.....

.....

GENERAL DETAILS

1. Building clearance, location of cage and bridge runway conductors are shown on accompanying drawing No.....
2. Speeds (with maximum working loads):

Main hoist.....fpm
Auxiliary hoist.....fpm
Bridge travel.....fpm
Trolley travel.....fpm

3. Distance top of runway rail to floor line..... ft..... in.
4. Total lift of hook above the floor line (exclusive of travel required to operate the limit switch):

Main hoist..... ft..... in.
Auxiliary hoist..... ft..... in.

5. Travel of hook below the floor line:

Main hoist..... ft..... in.
Auxiliary hoist..... ft..... in.

6. Span of crane, center line to center line of bridge runway rails..... ft..... in.
7. Minimum distance, centerline of main hook to centerline of bridge runway rail:

Cab end..... ft..... in.
End opposite cab..... ft..... in.

8. Minimum distance, centerline of main hook to centerline of auxiliary hook..... ft..... in.
9. Is repair structure over trolley to be furnished?.....
10. Are track sanders to be furnished?.....
11. Type of anti-friction bearings to be furnished on motors.....
12. Is safety handle on crane hook to be furnished?.....

13. Is safety latch on crane hook to be furnished?
14. Is lock to prevent hook from swiveling to be furnished?
15. Power for operating crane to be

SPECIFICATION DETAILS

The clause numbers with each of the following items indicate the following information supplements the corresponding clause number of the AISE Specification and is made a part of this specification. If this item is not applicable to the crane under construction, the item should be marked "not applicable."

1-A. Is latticed construction desired?
7-A. Crane to be erected by
8-A. Special tests are required as follows:

12-B. Color and quality of paint:
First coat
Second coat
13-A. The following special safety requirements must be met:

17-A-1-a. Maximum working loads:
Main hoist 1st trolley lb
2nd trolley lb
Auxiliary hoist lb
17-A-2-a. Condition of runways is
17-B. Are stress sheets required?
17-G-28. Minimum thickness of metal shall not be less than
17-G-36. Are wearing plates required under trolley runway rails?
17-N. Are breathing holes required in welded box girders?
17-P. Connection between girders and end trucks shall be as follows:

The method of attaching girders to end carriages during field erection shall be as follows:

18-G. Access shall be provided to the crane bridge from the crane runway as follows:

18-H. Are cranes with equalizer trucks to be provided with steel platforms?

19-A. Trolley frame construction shall be as follows:

20-A. Is full length foot-walk required on the idler girder?
22-A. Steps and ladders shall be provided as follows:

23. Type of cab shall be as follows:
23-F. Is air-conditioning ventilating or heating unit to be furnished?
If so, unit shall be of the following type and size:

24-A. Drum material shall be as follows:
25-A. Hoisting rope, grade and type shall be
28-A. Material for track wheels shall be
28-C. Track wheels shall be mounted as follows:

29-A. Crane runway rails are to be section No.
Trolley rails are to be section No.
29-C. Trolley rails shall be fastened to girders as follows:

30-C. Height of centerline on bumpers above top of crane runway rail shall be:

31-A. Bridge drive shall be in accordance with paragraph of clause No. 31.
31-B. The length of any section of the line shaft shall not exceed ft in.
31-E. Line shaft coupling shall be of the following type
31-F. The following items will have anti-friction bearings:

The following items will have sleeve bearings:

33-A. Type of fits for gears, pinions, wheels, couplings and so forth shall be:

34-A. Type and manufacturer of anti-friction bearing shall be as follows:

34-D. Lubricating fittings shall be fitted with grease or oil seals of the following type

36-A. Gearing shall be of the followng type:

36-B. Material used for gearing shall be from the following material class:

36-H. Brinell hardness of gears will be or as designed by contractor

37-C. Is bolted gear cover with gasket required:

37-E. Is allowance to be made in gearing housings to allow 15 per cent change in total gear ratio of drives?

38-A-2. Is second hoisting brake required?

38-B. Is trolley drag brake to be furnished?

38-C-3. Is safety dynamic braking to be furnished?

38-C-4. Are electro-hydraulic brakes required?

39-A. Size and type of lubrication fitting shall be as follows:

39-D. Is centralized lubrication system to be installed?

42. Type and number of collector shoes shall be as follows:

43. Crane service factors given in Table 43-III are satisfactory for use in computing motor sizes

43-B-2-a. Are crane runway friction factors of 15 lb per ton for roller bearings and 24 lb per ton for sleeve bearing cranes satisfactory?

43-B-2-b. Required crane acceleration will be as follows:

44. Control panel shall be located as follows:

44. Relative position of master control switches shall be as follows:

44-A. The magnetic control to be used on trolley shall be

44-B-5. Resistors shall be of the following type and have the following NEMA classification numbers:

The location of the resistors will be as follows:

44-C. Is control panel enclosure required?

When required, control panel shall be in accordance with the following NEMA classification:

45-C. Limit switches may be of the type described in paragraph 45-C.

46-B. What means for operating the safety switch on the foot-walk are to be provided in the cab?

48-A. Are magnet cable reels required?

The type of magnet cable reel will be as follows:

Is magnet reel to be furnished by purchaser or seller?

Is extra flexible magnet cable to be furnished by purchaser or seller?

Magnet control will be furnished by

Magnet control will be installed by

When magnet is not specified, is space to be provided on trolley for future mounting of magnet cable reel?

48-B. Is disconnect clutch for magnet cable reel required?

49-B. Lighting fixtures shall be furnished as follows (size and number):

50-A. Signal lights shall be furnished as follows (size and number):

SPECIAL FEATURES

AISE CRANE SPECIFICATIONS

CONTRACTOR'S INFORMATION SHEETS

.....Company
.....Works
Located at.....
Specification No..... Dated.....

For

.....TON ELECTRIC OVERHEAD TRAVELING CRANE

The data called for below are to be furnished by the bidder, and in case the bidder becomes the contractor, the data shall form part of the contract covering the work.
(If motors are furnished by purchaser, the contractor shall specify the hp and rpm of the motors he recommends.)

1. Name of bidder.....
2. Date of proposition.....
3. Is it the bidder's intention, if awarded the contract, to comply fully and in all respects with purchaser's specifications covering the work? If not, bidder shall state exceptions in detail.....
4. Time in which contractor will agree to deliver or complete all work covered by these specifications.....
5. Lump sum price for which contractor will agree to.....
.....ton electric overhead traveling crane as covered by these specifications.

(Where the specifications require consideration be given to the use of high tensile steels for crane girders, a separate price shall be quoted for crane with high tensile steel girders. The saving in weight due to the use of these high tensile steels shall also be given.)

6. Amount included in above lump sum price for:

Motors..... $.....
Control..... $.....
Magnetic brakes..... $.....
Hoist limit switches..... $.....

7. Number of cranes furnished.....
8. Total weight of crane including electrical equipment.....
9. Total weight of trolley including electrical equipment.....
10. Weight of each bridge girder as assembled ready for erection.....
11. Weight of each end carriage as assembled ready for erection.....

	Main hoist	Auxiliary hoist
12. Hoists:		
Speed, feet per minute		
A. With maximum working load		
B. With empty hook		
Ropes, size		
Number of rope parts supporting the load		
Diameter of drum		
Material in drum		
Diameter of sheaves		
Hp of motor at mill rating		
Rpm of motor at mill rating		
Computed required hp of motor (Par 43B1) (No service factor)		
Make and type of motor		
Make and type of hoist limit switch		
Total lift above floor line (exclusive of travel required to operate limit switch)		
Total travel below floor line		
Brakes, number, make and size		
Make and type of bearings		
Make, size and type of worm gear drive, if furnished		

13. Trolley:

Speed, feet per minute with maximum working load.....
Wheel span.....
Wheel base.....
Diameter of wheels.....
Maximum wheel load.....
Size of trolley runway rail.....
Hp of motor at mill rating.....
Rpm of motor at mill rating.....
Computed required hp of motor (Par 43B2) (No service factor).....
Service factor used.....
Make and type of motor.....
Make and type of brake, if furnished.....
Make and type of bearings.....
Make, size and type of worm gear drive, if furnished.....
Is foot-walk provided on ends of trolley?.....

14. Bridge:

Speed, feet per minute with maximum working load.....
Wheel base.....
Diameter of wheels.....
Number of wheels on each end of crane.....
Maximum wheel load.....
Make, type, size, and maximum load on wheel axle bearings.....
Number of motors.....
Hp of motors at mill rating.....
Rpm of motors at mill rating.....
Computed required hp of motor (Par 43B2) (No service factor).....
Service factor used.....
Make and type of motors.....
Diameter of drive shaft.....
Make, type and size of line shaft bearings.....
Number and size of brakes.....
Make and type of brake operating equipment.....
Clear width of each foot-walk.....
Number of outrigger girders.....
Distance, centerline to centerline of girders.....
Type of sanding device, if furnished.....
Girders:
Submit design drawing showing overall dimensions, size of each section and location and depth of diaphragms.

15. Controls, make and type (if furnished by contractor):

Hoist motor.....
Bridge motor.....
Trolley motor.....
Location of magnetic control panels.....

16. Minimum distance centerline of main hook to centerline of runway:

Cab end.....
End opposite cab.....

17. Distance centerline to centerline of main and auxiliary hooks.....

18. Distance centerline between girders to extreme outside of crane:

Cab side.....
Side opposite cab.....

19. Distance, bottom of cab to floor.....

20. Clearances:

Bridge truck and building column.....
Trolley and roof chord.....

21. Make and type of flexible couplings.....
22. Size of cab.....
23. Maximum deflection of girders under maximum working load.....
24. Wiring, trade name, and classification of wire insulation.....

.....

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Track wheels....CS13
Trolley brakes....CS29
Trolley frames....CS10
Trolley motor....CS31

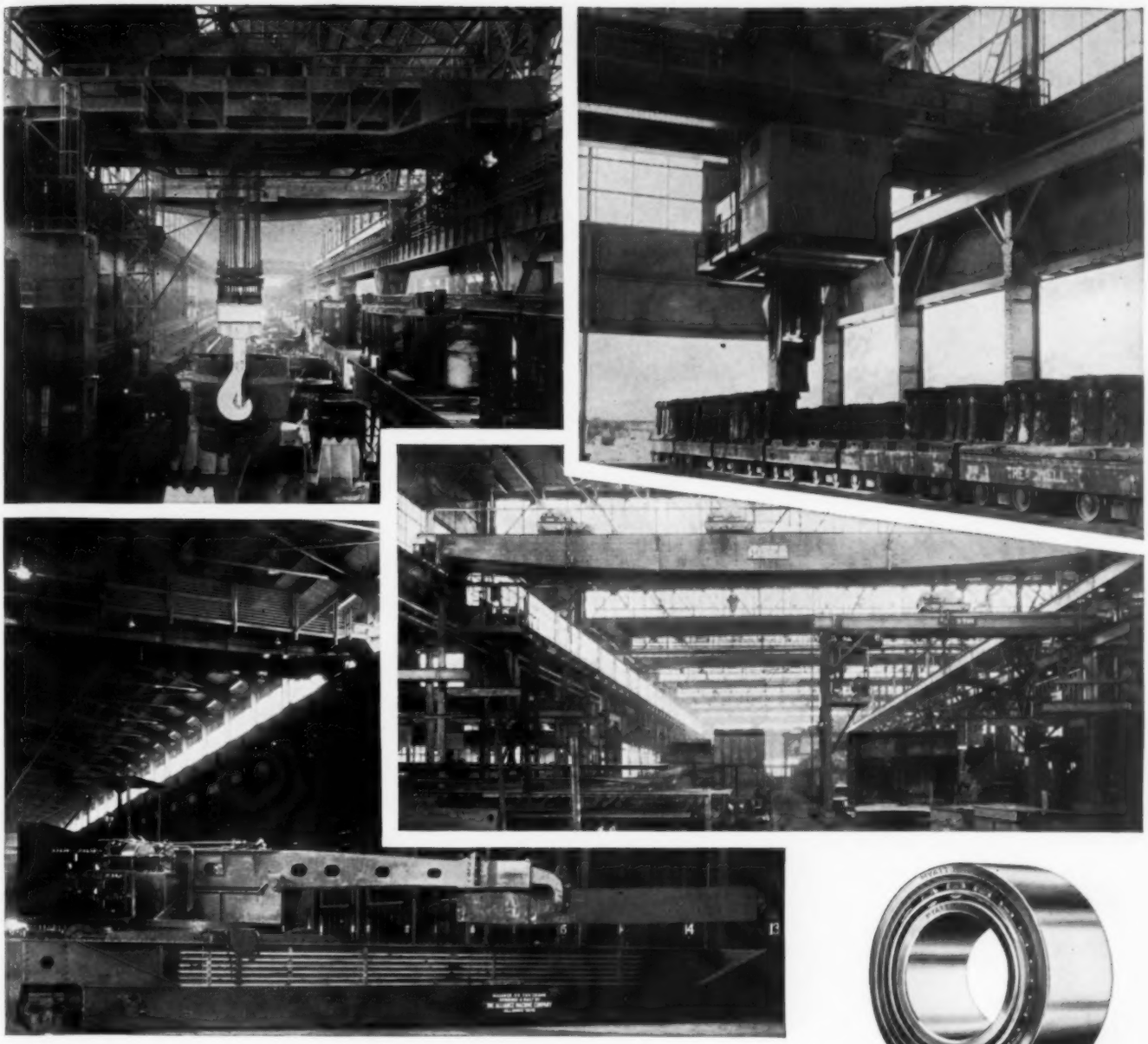
W

Welded construction....CS5
Wheels, Track....CS13
Wind load....CS6
Wiring....CS34
Workmanship, material and inspection....CS4

AISE STANDARD NO. 6
(*Revised May 1, 1949*)

For additional copies write ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 Empire Building, Pittsburgh 22, Pa. $1.00 each — Quantity prices on request

Printed in USA



In Steel Mill Cranes...It's HYATT

Yes, Hyatt Roller Bearings predominate in all types of electric over-head traveling cranes and open hearth charging machines.

With Hyatt Roller Bearings at all turning points in the bridge and trolley, in motors and sheaves, smoother, quieter operation with reduced power and maintenance is the result. Hyatts provide easy rolling for accurate spotting, shafts are kept in alignment with wear eliminated and the fraying of cables is minimized by free turning sheaves.

In addition to their application in cranes, Hyatt Roller Bearings also have a long record of successful operation in cars, tables and other auxiliary equipment. That's why Hyatt Roller Bearings are so consistently specified for new equipment and so extensively used for changeovers. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

FOR *Constant* CONTACT FROM CONDUCTOR TO CRANE

KEYSTONE CONTACT RAIL SHOES

Constant contact with the conductor *regardless of misalignment in the conductor — that's* what makes the Keystone Contact Rail Shoe so popular in the nation's steel mills.

Pressure of the contact member, 2½ x 4½" in area, is maintained by a spring held under compression. The amount of pressure exerted by the spring is easily adjusted by turning a single bolt to the precise level desired. In addition to this wide range of vertical adjustment, the Keystone Contact Rail Shoe is also completely reversible . . . adaptable to both over-running and under-running service.

To bond the hinged portion of the shoe, flexible copper connection cables extend from the upper bronze connecting block direct to the contact member. The cable terminal lug is designed for feeder cables to enter from either the top or side, thus providing greater adaptability.

Ruggedly constructed of but a few simple parts, this Keystone Rail Shoe is the answer to dependable contact wherever a conductor is an angle or a tee rail. Detailed information is available in our catalog, "Keystone Industrial Products". Write for your copy.

Keystone Contact Rail Shoe Over-Running a Tee Rail Conductor.

ELECTRIC SERVICE MANUFACTURING CO.

1721 CAMBRIA ST. PHILADELPHIA 32, PA.

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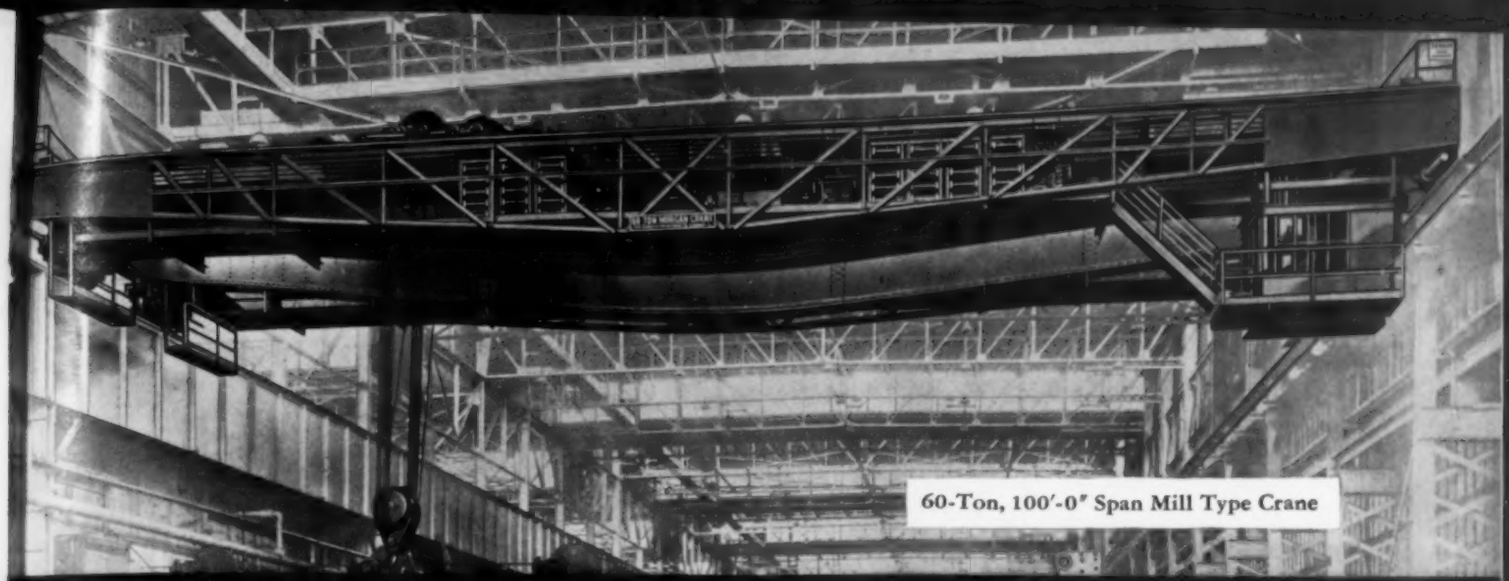
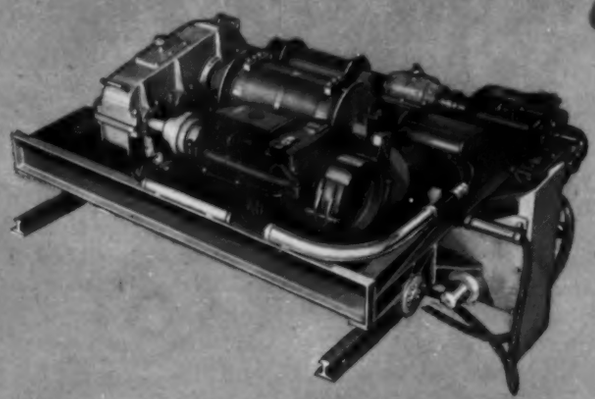


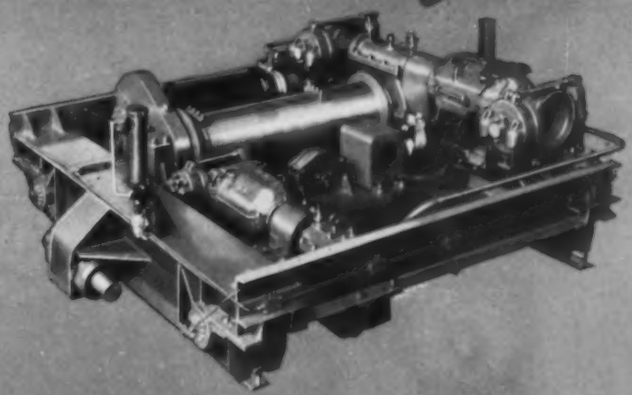
60-Ton, 100′-0″ Span Mill Type Crane

TYPICAL MILL TYPE CRANES BUILT TO A. I. & S. E. SPECIFICATIONS

BUILT BY MORGAN *Engineering*

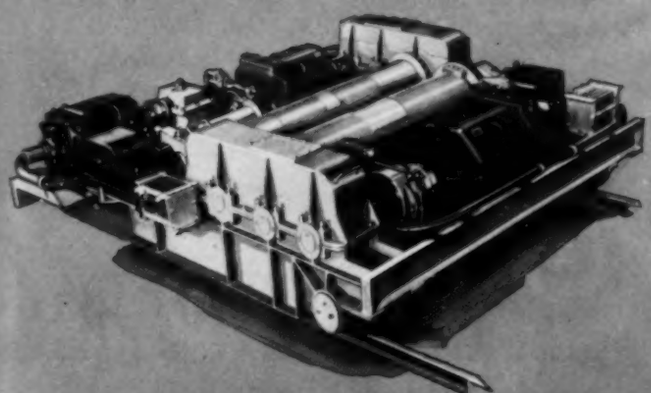


10-Ton Gear Box Type Trolley

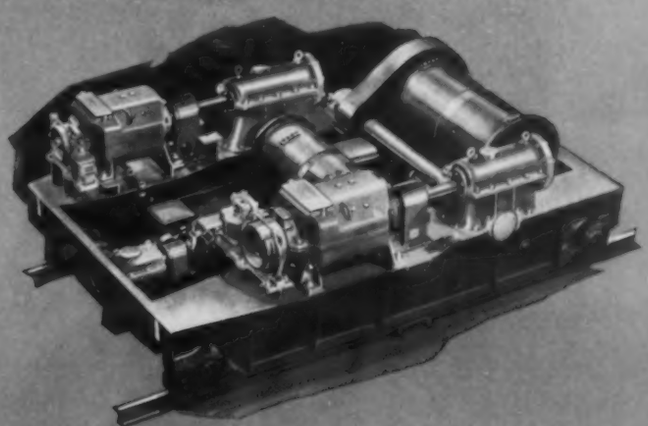


10-Ton Worm Type Trolley

30-Ton Gear Box Type Trolley

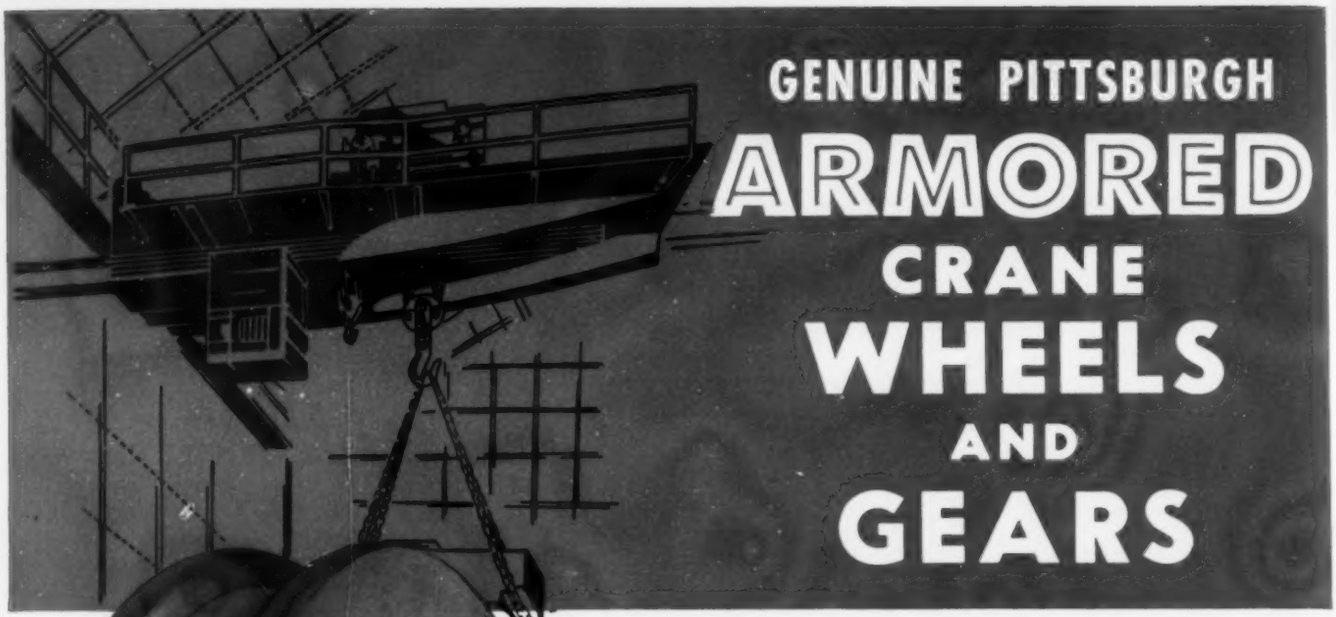


60-Ton Worm Type Trolley



THE MORGAN ENGINEERING CO., ALLIANCE, OHIO • PITTSBURGH—1420 OLIVER BUILDING

DESIGNERS • MANUFACTURERS • CONTRACTORS • BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS • ELECTRIC TRAVELING CRANES • CHARGING MACHINES • INGOT STRIPPING MACHINES • SOAKING PIT CRANES • ELECTRIC WELDED FABRICATION LADLE CRANES • STEAM HAMMERS • STEAM HYDRAULIC FORGING PRESSES • SPECIAL MACHINERY FOR STEEL MILLS



GENUINE PITTSBURGH ARMORED CRANE WHEELS AND GEARS

"JUST THE RIGHT HARDNESS IN JUST THE RIGHT PLACES"

They're STRONGER, SHOCK RESISTING, LONGER LASTING!

Yes, PITTSBURGH ARMORED CRANE WHEELS are unequalled when it comes to long, trouble-free service! Day in, day out they reduce work stoppages, cut replacement and maintenance costs, and make your dollars go farther. These TRIPLE savings stem from the EXTRA-HARD treads and flanges . . . and the tough, shock resisting cores. Available from 10" to 30" diameters. Treads: flat, taper, radius, "Pittsburgh Gear" or Association of Iron and Steel Engineers Standard. Bores and hubs machineable.

Like ARMORED Crane Wheels, GUARANTEED PITTSBURGH ARMORED GEARS will give you longer, more satisfactory service than you've known. They are *guaranteed* to outlast untreated gears 5 to 1; and to equal or excel *any* other heat treated gear. Switch to them today!

PROMPT DELIVERIES FROM STOCK BLANKS . . . TO YOUR *"Tailored"* SPECIFICATIONS

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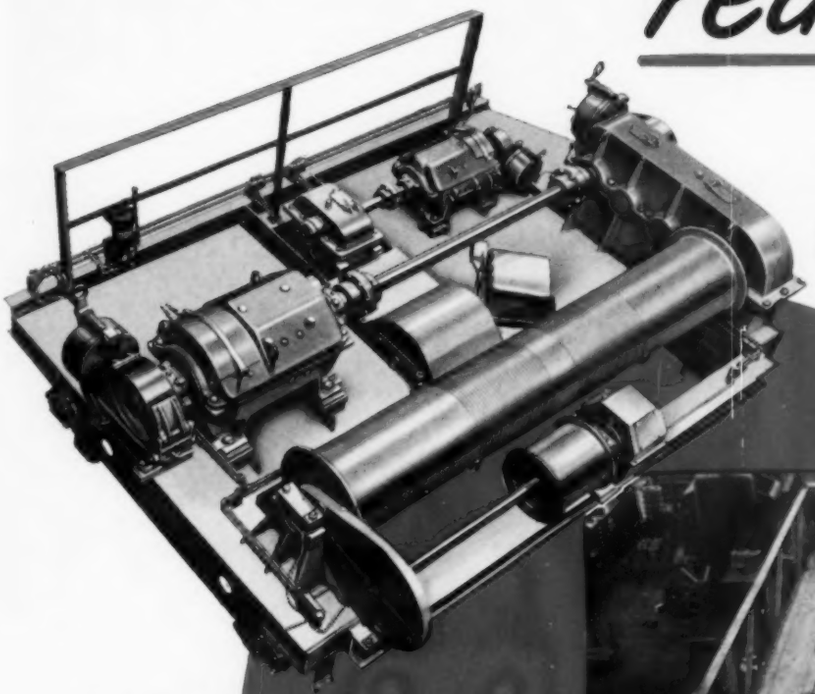
. . . PRODUCERS OF *Guaranteed* ARMORED GEARS

P&H MILL TYPE CRANES

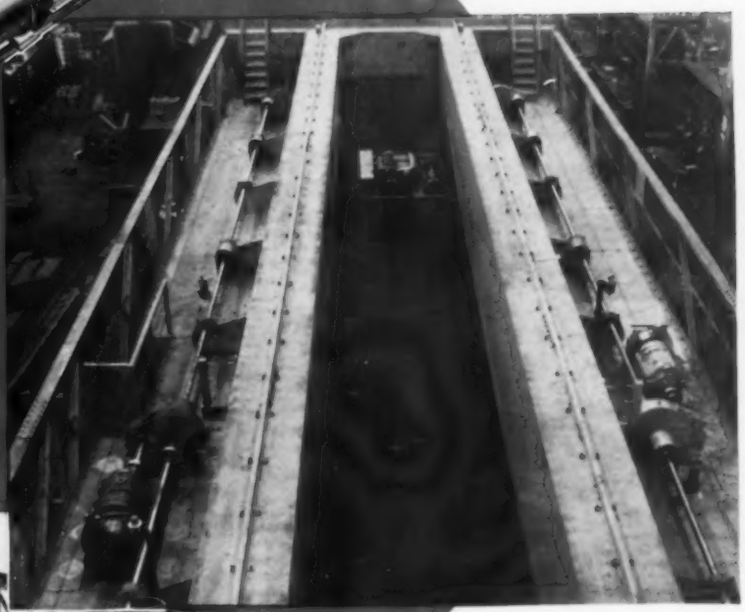
redesigned

to meet new

I.&S.E. specifications



Enclosed gearing throughout, including drum gear. All gears run in oil bath; no more dripping grease. Head sheaves accessible above trolley deck.



Three gear case bridge drive with all gears running in oil bath.

And a multitude of other advanced mill design features you will want to know about. Write for information.

P&H

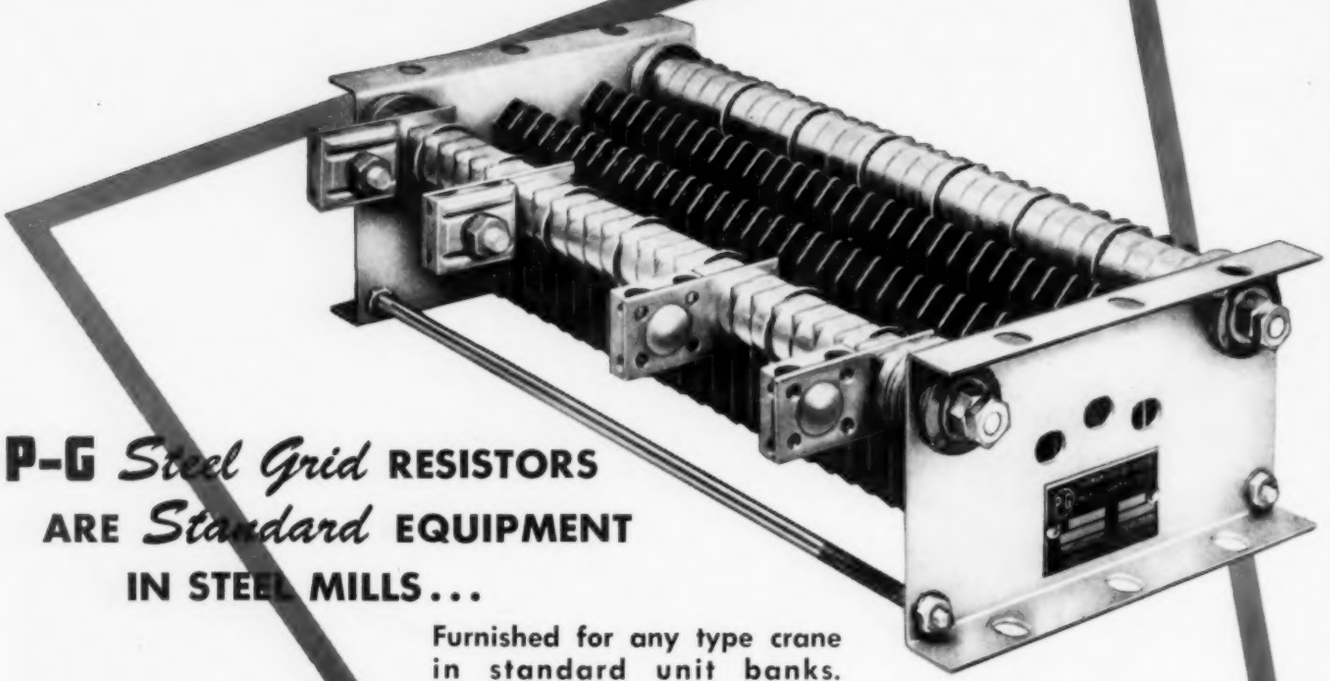
MILL TYPE CRANES
4455 W. National Avenue
Milwaukee 14, Wisconsin

HARNISCHFEGER CORPORATION

ELECTRIC CRANES · EXCAVATORS · ARC WELDERS · P&H · HOISTS · WELDING ELECTRODES · MOTORS

AMERICA'S LEADING BUILDER OF OVERHEAD ELECTRIC CRANES

E O T CRANE *Resistors*

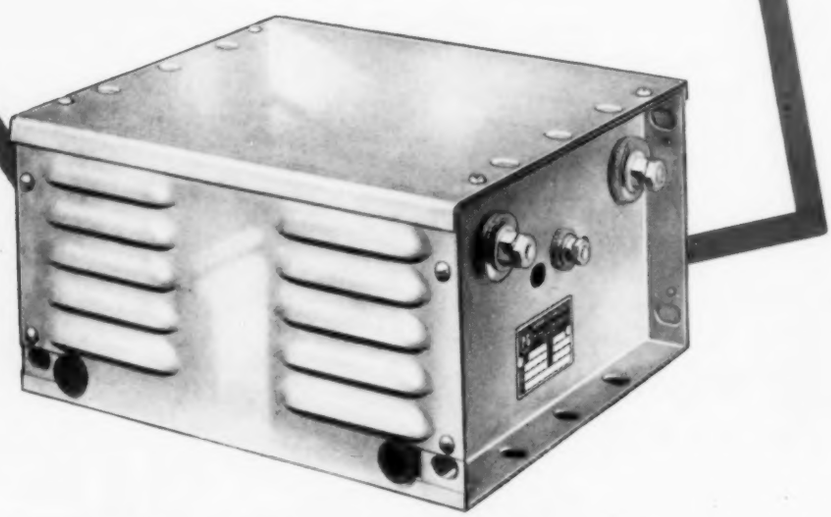


P-G *Steel Grid* RESISTORS ARE *Standard* EQUIPMENT IN STEEL MILLS...

Furnished for any type crane in standard unit banks.

P-G RESISTORS *for* SAFETY LIMIT STOPS

Available in standard units for any size motor.



Complete data given in **BULLETIN No. 500 . . .** Copy on request.

Specify P-G for continuous trouble-free service

P-G

The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO

BIG CRANES

For fifty years, The Alliance Machine Company has been a leader in the designing, engineering and building of giant cranes for heavy industry. Many safety and mechanical features now accepted as standard practice in steel mill cranes, were first introduced by Alliance. In open hearth cranes, these features include interlocked drums, synchronized worm drive, 4-girder bridge construction, safety rope reeving and laminated ladle hooks. For increased safety, these hooks are equipped with universal joints at the top, permitting them to swing freely in any direction, thus preventing the hooks from bending and shearing rivets due to accidental collision.

The Alliance Machine Company has designed and built thousands of big cranes of all types to move heavy loads safely and economically. Give us an opportunity to solve your crane problems.

THE ALLIANCE MACHINE COMPANY

MAIN OFFICE
ALLIANCE, OHIO

PITTSBURGH OFFICE
1622 OLIVER BUILDING, PITTSBURGH, PA.

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES
STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH
CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION

Is UPKEEP COST your magnet problem?

Although it looks and lifts like new, this Ohio Magnet is actually 22 years old. Until recently, upkeep cost was zero. Then a ground developed in the terminal box and the magnet was shipped to our plant, where repairs were quickly completed without disassembly.

Upkeep cost? Under $100—*less than $5 a year for 22 years!*

Next time you buy a lifting magnet, remember that heavier construction assures extra years of low-cost life. Send your order to Ohio—*25 years a leader in magnetic materials handling.*

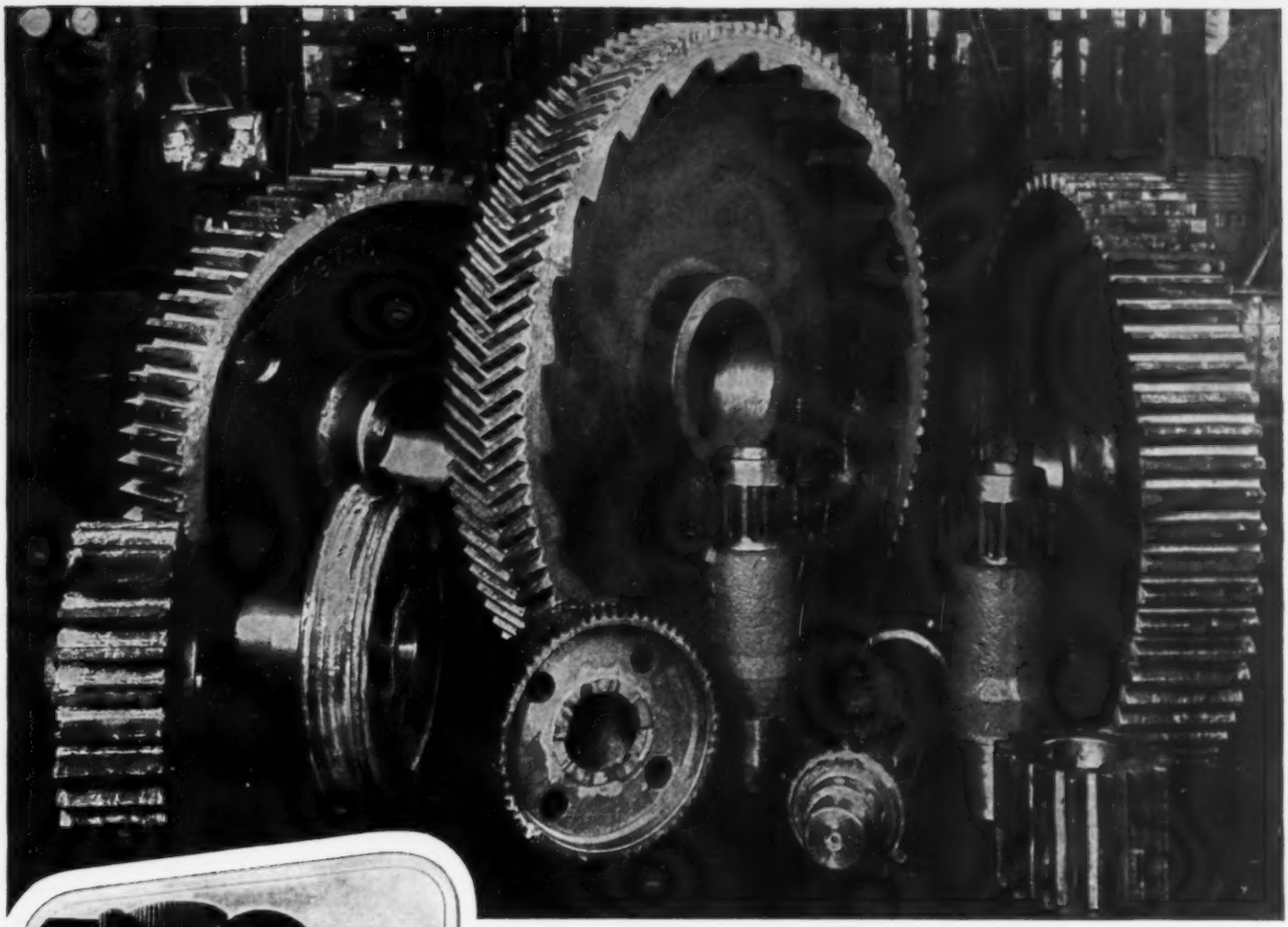
This magnet averaged less than $5 a year!

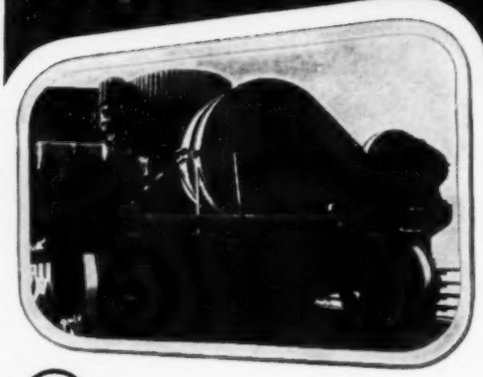
OHIO PROTECTO-WELD MAGNET is welded *on top*, where weld cannot be dented in. Sizes include 39, 46, 55 and 65-inch diameters. Ohio also builds magnet control equipment.

THE OHIO ELECTRIC MFG. CO. • 5900 MAURICE AVENUE • CLEVELAND 4, OHIO

ohio MAGNETS

A-2012





CRANE GEARS and TRACK WHEELS have *Greater Internal Stress Value* . . .

HERE IS WHY

FOR COMPARATIVE PURPOSES

we tabulate below the physical properties of the surface and core values of SAE-1020, SAE-2315, Steels, Carburized or Case Hardened with "NELOY" and "NELOY-MOLY" Steels Normalized or Liquid Quenched, Finish Machined and Flame Hardened.

	Ultimate Tensile Lbs. per Sq. In.	Elastic Limit or Yield Point Lbs. per Sq. In.	Elongation Percent	Reduction of Area Percent	Brinell	Sclero-scope
S.A.E. 1020 Case Hardened (Surface)...	260/300,000	180/195,000	5–10	8–12	514–601	71–81
S.A.E. 1020 Case Hardened (Core).....	60/ 70,000	30/ 35,000	30–35	40–50	120–140	17–20
Neloy Annealed and Flame Hardened Treatment 10B (Surface).....	218/270,000	190/240,000	8–12	20–35	477–590	66–80
Neloy Annealed and Flame Hardened Treatment 10B (Core).....	85/ 90,000	55/ 65,000	23–40	30–40	163–170	23–24
S.A.E. 1020 Case Hardened (Surface)...	260/300,000	180/195,000	5–10	8–12	514–601	71–81
S.A.E. 1020 Case Hardened (Core).....	60/ 70,000	30/ 35,000	30–35	40–50	120–140	17–20
Neloy Heat-treatments No. 3 and 10B (Surface).....	220/270,000	200/240,000	8–12	20–35	550–590	68–80
Neloy Heat-treatments No. 3 and 10B (Core).....	100/110,000	80/ 90,000	20–26	40–50	202–240	29–33
S.A.E. 2315 Case Hardened (Surface)...	290/329,000	185/205,000	4– 8	6–10	570–653	78–87
S.A.E. 2315 Case Hardened (Core).....	112/129,000	99/120,000	12–20	38–51	249–275	35–39
Neloy-Molybdenum, Normalized, Drawn and Flame Hardened (Surface)	258/281,000	212/247,000	6–10	8–12	514–555	71–75
Neloy-Molybdenum, Normalized, Drawn and Flame Hardened (Core)	90/110,000*	65/ 85,000*	18–25	30–40	190–220	28–33
S.A.E. 2315 Case Hardened (Surface)...	290/329,000	185/205,000	4– 8	6–10	570–653	78–87
S.A.E. 2315 Case Hardened (Core).....	112/129,000	99/120,000	12–20	38–51	249–275	35–39
Neloy-Molybdenum Heat-treatments 3A and 10B Flame Hardened (Surface)	282/318,000	217/265,000	4– 8	6–10	555–627	75–84
Neloy-Molybdenum Heat-treatments 3A and 10B Flame Hardened (Core)	132/150,000	120/135,000	10–18	25–35	290–320	41–45

***The variation in tensile and yield in the third table is due to the alloyed elements of 2315 which is a nickel steel. This produces a higher physical on a straight annealed steel compared with more economical alloy used in Neloy Moly.**

NATIONAL ERIE CORPORATION

ERIE, PENNSYLVANIA • U. S. A.

Cranes Built to AISE "

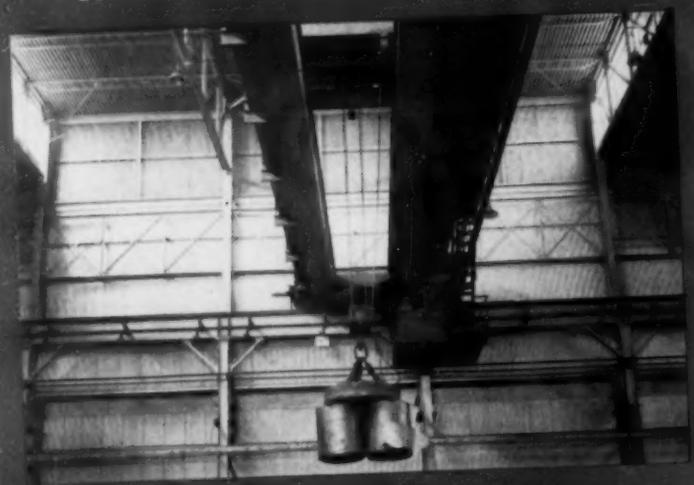
Cleveland Steel Mill Cranes Meet or Exceed *ALL* AISE Specifications

● For many years Cleveland Crane has worked closely with the Association of Iron and Steel Engineers and the Steel Industry in the drafting of overhead crane specifications that adequately cover the hard requirements necessary for proper mill performance.

Cleveland knows the "specs" and designs mill cranes in accordance with them. All Cleveland mill-type cranes meet or exceed AISE Specifications for Electric Overhead Traveling Cranes for Steel Mill Service.

THE CLEVELAND CRANE & ENGINEERING CO.
1131 EAST 285TH ST. WICKLIFFE, OHIO

10 Ton, 100'-0" Span Magnet Crane



Four 15 Ton, 120'-0" Span Cranes

SOME OF THE MILLS BEING SERVED BY CLEVELAND ALL-WELDED MILL-TYPE CRANES

Allegheny Ludlum Steel Corporation
Atlantic Steel Company
Brazilian National Steel Co.
Carnegie-Illinois Steel Corporation
Continental Steel Corporation
Crucible Steel Company of America
Ford Motor Company
Geneva Steel Company
Jones & Laughlin Steel Corporation
National Tube Company
Pittsburgh Steel Company
Republic Steel Corporation
Rotary Electric Steel Co.
Tennessee Coal, Iron and Railroad Company
Weirton Steel Company
Wheeling Steel Corporation
The Colorado Fuel and Iron Corporation

"Specs"!

Scrap yard crane with two trolleys, one with 50 ton main hoist and 15 ton auxiliary hoist; other with 20 ton double drum hoist for 70 cu. ft. bucket. Span is 80'-0".

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

feathers or locomotives get a smoother, easier lift . . . on SKF Bearings

The SKF Spherical Roller Bearing is used on all types of cranes . . . from small hoists to locomotive or overhead cranes, some of which have capacities up to 450 tons.

That kind of versatility is a feature of the SKF line. And added to this is the ability of these quality bearings to withstand the heavy shock loads and overloads inherent in crane operation. SKF Bearings compensate for inaccuracies in fabrication and machining . . . without loss in capacity.

SKF Bearings find application in wheel and drum mountings, and are preferred by men who design the equipment. Your problems will be brought to the prompt attention of our bearing engineers. SKF Industries, Inc., Phila. 32, Pa.

6664

Crane and Hoist Bearings engineered by SKF

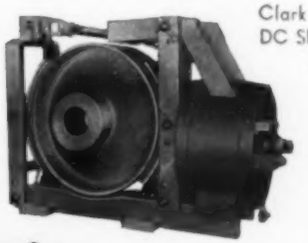
CLARK offers ALL CONTROL EQUIPMENT for SAFE, EFFICIENT CRANE OPERATION

from one reliable source!

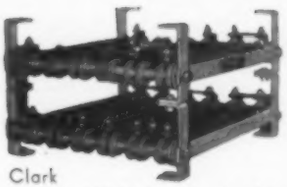
CLARK standard crane control apparatus provides dependable, safe operation. Whatever your Crane Control specifications are, CLARK control will meet all your requirements.

Clark Bulletin 101-RD Master Switch for Mill and Crane Control

Clark Bulletin 102-CHL Crane Hook Limit Switch

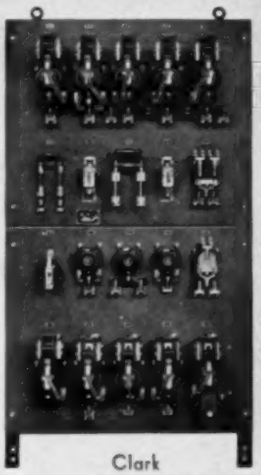


Clark Bulletin 106 DC Shoe Brake



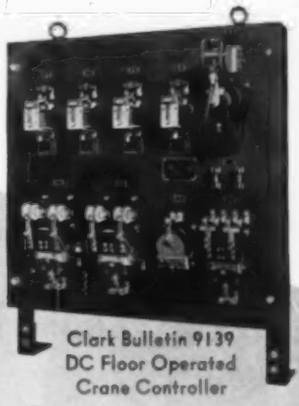
Clark Bulletin 110 Edgewound Resistor

Clark Bulletin 9230 AC Magnetic Crane Controller—Reversing



Clark Bulletin 9135 DC Crane Hoist Controller

Clark Bulletin 9136 DC Crane Hoist, Bridge and Trolley Controller

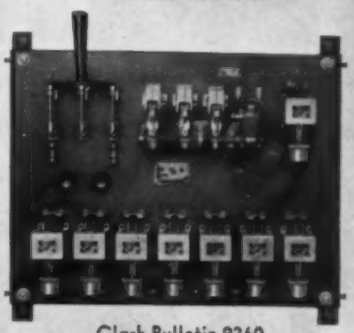


Clark Bulletin 9139 DC Floor Operated Crane Controller

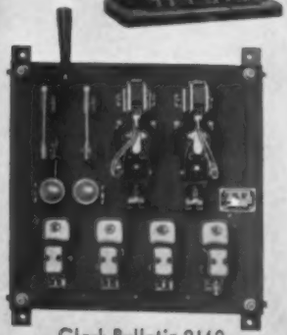
Clark Bulletin 9250 Size No. 2 Reversing AC Manual Face Plate Controller

Pendant Type Push Button Station for Bulletin 9135 Floor Operated Crane Controller

Pendant Type Push Button Station for Bulletin 9135 Floor Operated Crane Controller



Clark Bulletin 9260 AC Crane Protective Panel

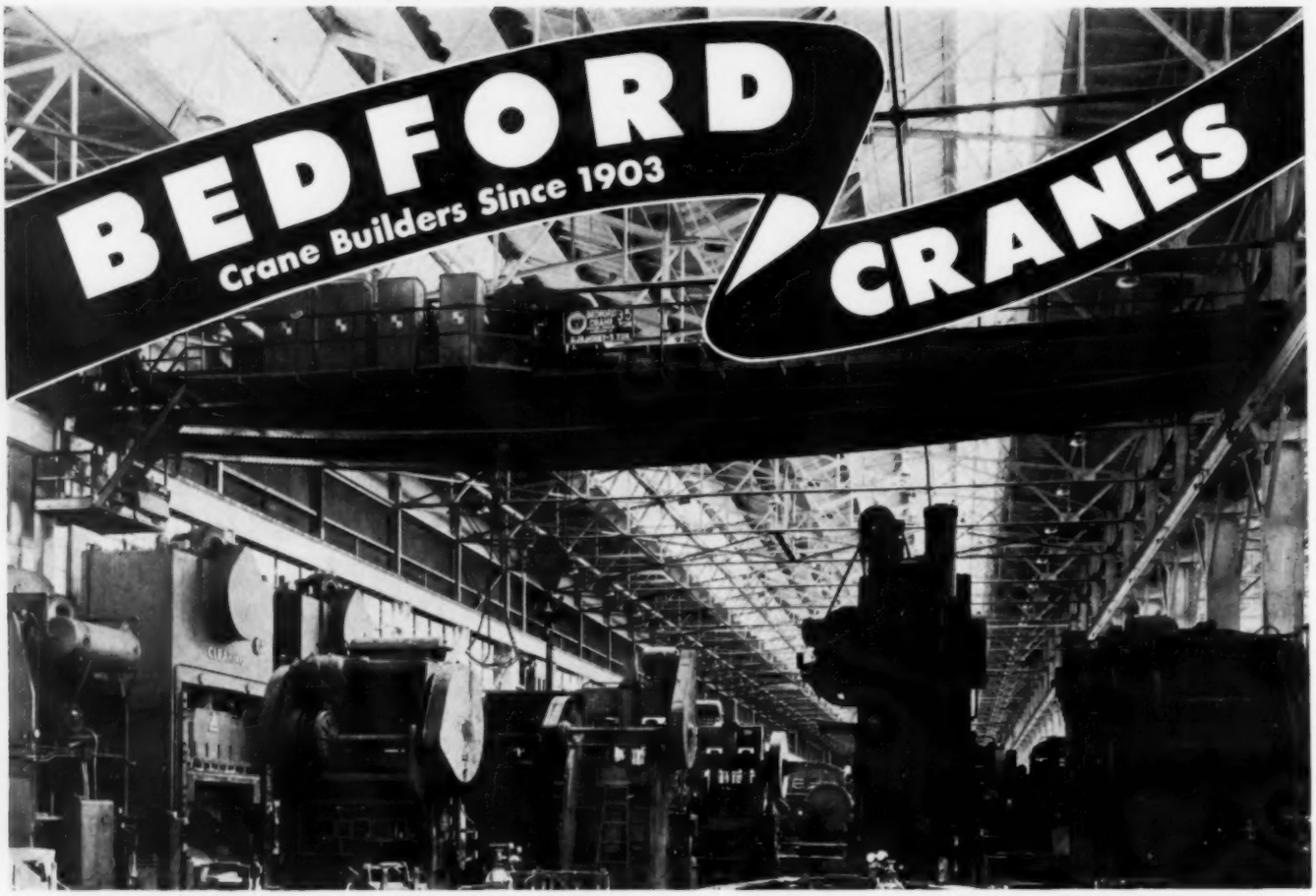


Clark Bulletin 9160 DC Crane Protective Panel

LET US HELP YOU WITH YOUR Crane Control PROBLEMS

THE CLARK CONTROLLER CO.

EVERYTHING UNDER CONTROL • 1146 EAST 152nd STREET, CLEVELAND 10, OHIO



35 ton capacity, 5 ton auxiliary, 4 motor, 80'0" span, AC, full magnetic electric overhead traveling crane.

ANY SPAN or LIFT . . .

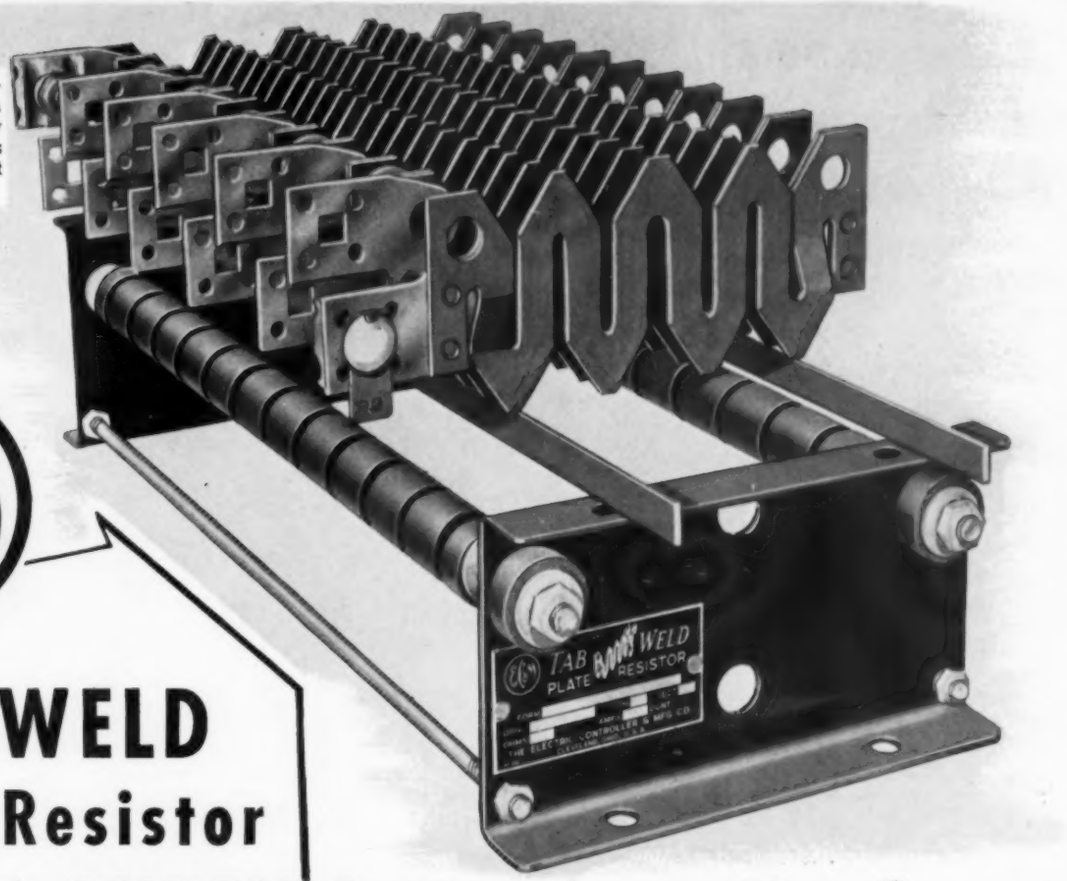
Capacities 5 to 150 Tons

This distinguished record rates an award of merit, particularly since it reflects the good relations we have enjoyed with our customers as well as the efficient service we have rendered. This backlog of experience is one of our major assets: we suggest that you consider it when you contemplate buying electric overhead traveling cranes, gantry cranes, steel derricks built to specifications, structural steel, steel buildings and gray iron castings.

Write for catalog and complete data.

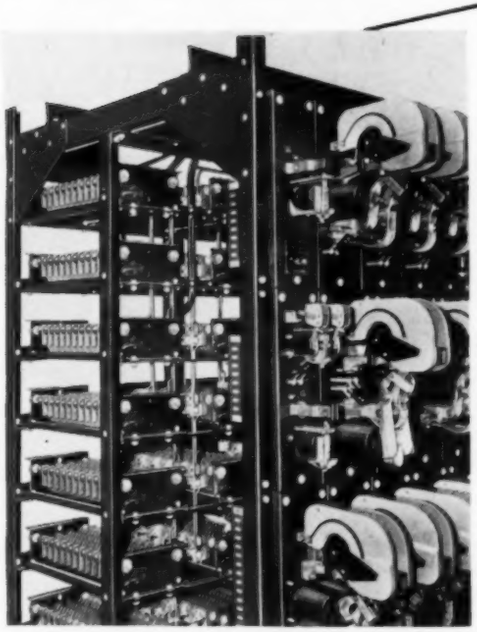
BEDFORD FOUNDRY & MACHINE CO.
Bedford, Indiana, U.S.A.

The welded grid assembly is shown here as a unit resting on narrow iron straps above its end frame, support rods, and spacers.



TAB-WELD Plate Resistor

Steps Up RESISTOR Performance these 3 ways



TAB-WELD Resistors as part of Factory-assembled Control for recent Ore-Bridge Installation.

The *welded* grid-assembly of the EC&M TAB-WELD Plate Resistor reduces resistor maintenance costs and improves operation.

HERE'S HOW:

1. **Stabilizes** the Ohmic Value—A continuous path for current is maintained *independent* of the clamping-nuts.
2. **Stops burning** at grid-eyes and at tap-plates. Trouble is eliminated in these concealed areas due to *intimate* contact maintained by welding.
3. **Simplifies** Tap-Shifting—(a) when adjusting resistance to improve motor operation on an existing installation; (b) when necessary to replace a section, a standard mill section can be taken from the storeroom and used *without change* . . . External connections can be made to any one of the several tap-plates; only the external lead and terminal block need be moved to give the desired operation.

For low-cost, trouble-free operation, make up resistor layouts with EC&M Bulletin 942 TAB-WELD Plate Resistor Sections, made from corrosion-resistant steel.

THE ELECTRIC CONTROLLER & MFG. CO.
2698 EAST 79TH STREET • CLEVELAND 4, OHIO

TYPE "LBW"

THE RIGHT CONDUCTOR RAIL SUPPORT FOR MAXIMUM SAFETY, STRENGTH AND CONTINUITY OF SERVICE

Type "LBW" inverted conductor rail support.

These inverted supports have the advantage that dirt, sleet and ice do not collect easily on the contact surface of the rail. Notched clamp and grips plus one half-inch vertical adjustment on the supporting bolt provide for slight misalignment and various sizes of rail.

Porcelain is in compression between forged steel housing and rail supporting bolt head. Weight is uniformly distributed by lead washers which cushion the porcelain against abnormal strains. A formed brass washer supplies the bearing surface between the bolt head and lead washer — bolt cannot pass through the housing hole. In the event of porcelain failure due to accidental impact or overloading, the rail will not drop. An insulating disk covers the bolt head and the entire assembly is compound sealed against moisture; insuring high dielectric values.

Insulators are of high grade wet process porcelain finished in chocolate brown glaze. These supports are conservatively rated at 750 volts.

Many special supports are available for use with rails, angles, T-bars or flat bars.

DELTA-STAR ELECTRIC COMPANY

MAIN OFFICE AND FACTORY — 2400 Block, Fulton St., Chicago 12, Ill.

NEW YORK OFFICE — 140 Cedar St., New York 6, N. Y.

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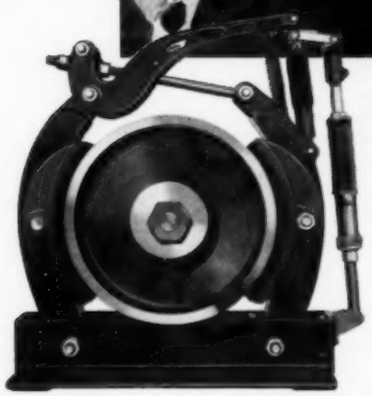
CANADIAN ASSOCIATE

Canadian Line Materials Limited — Toronto 13, Canada

DON'T LET THIS HAPPEN TO YOUR CRANE . . .



Equip with *WAGNER* Hydraulic Crane-Bridge Brakes for *SAFE, SURE STOPS*

Only Wagner crane-bridge Brakes give you all *these features:*

• A Size and Type for Every Application . . .
Wagner hydraulic crane-bridge brakes are built, with or without parking attachment, in four sizes that are capable of handling any application—from light industrial cranes to the largest steel mill ladle crane.

• Remote Control Bleeder . . .
Keeps lines full of fluid, even when brake is installed at a considerable height above the control cylinder. Maintains peak braking efficiency, and makes bleeding the system an easy, "one-man" job.

• Self-Centering Device . . .
Prevents brake shoe drag by assuring equal clearance of both brake shoes.

• Other Advantages Include . . .
Power failure braking . . . one-point shoe adjustment . . . 200% emergency torque . . . grease fittings for lubrication . . . non-scoring, easily replaceable molded lining blocks.

* * *

If your cranes are not equipped with Wagner brakes, one of our field engineers will gladly show you how simple it is to install a modern hydraulic system.

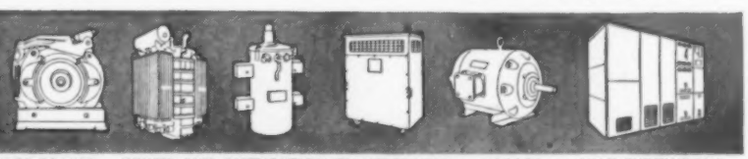
If you now have Wagner brakes, your system can be quickly modernized with our complete conversion kits. You can change your old solenoid-controlled HM brake to the compact, hydraulic type; you can convert a type H brake to an HM; and you can easily add the remote control bleeder to any Wagner system.

Bulletin IU-40 gives full information on Wagner Industrial Brakes—write for copy.

Wagner Electric Corporation
6483 PLYMOUTH AVE., ST. LOUIS 14, MO., U. S. A.

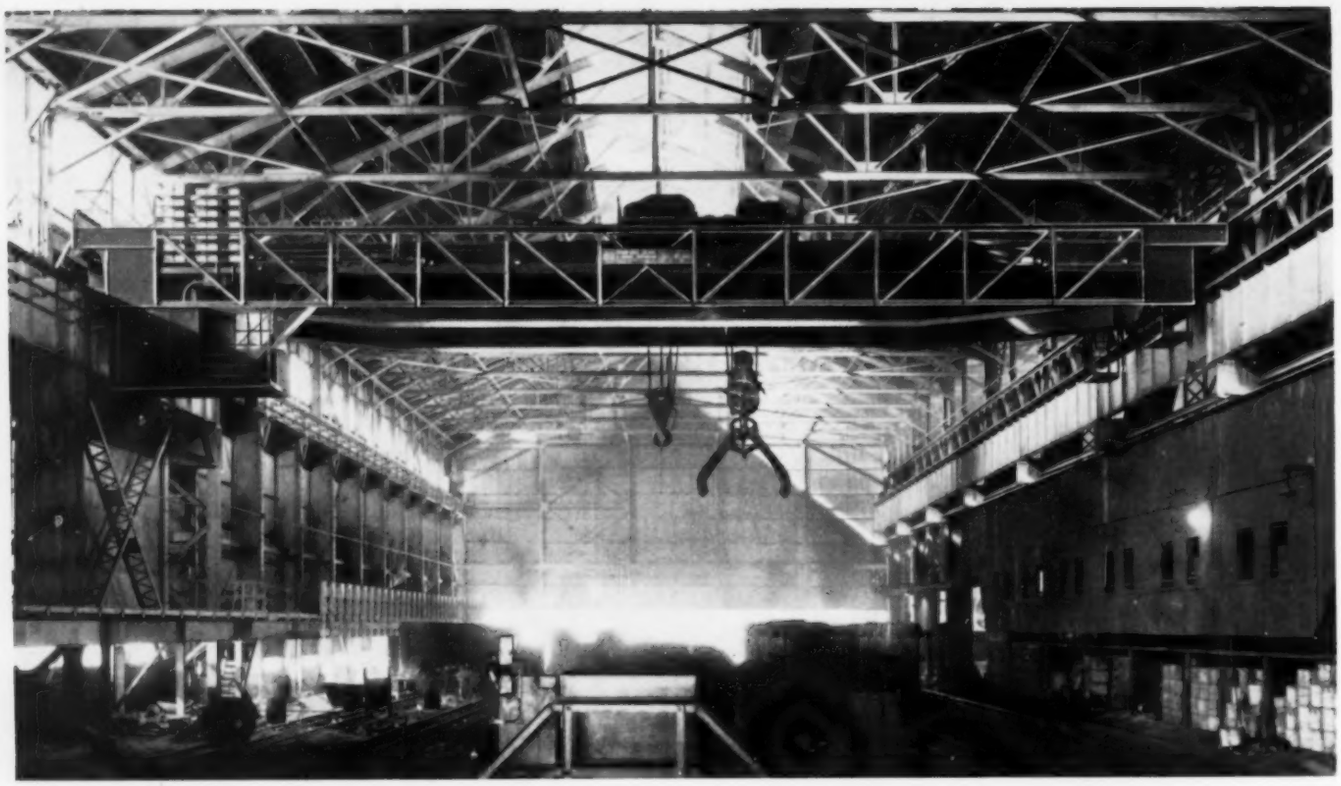
Consult Wagner Engineers on all Crane-Bridge Braking Problems

Wagner Electric Corporation
EST. WE 1891



BRIDGE BRAKES • POWER AND DISTRIBUTION TRANSFORMERS • MOTORS • UNIT SUBSTATIONS
ELECTRICAL EQUIPMENT AND AUTOMOTIVE BRAKE PRODUCTS

149-3



Specifications by AISE
···CRANES BY "*Shaw-Box*"

When "Shaw-Box" builds your Mill Cranes you get cranes built exactly to specifications plus meeting the spirit and intent of the specifications. And, you also obtain in them all the advantages of "Shaw-Box" experience and precision manufacturing practices.

Built to exacting standards of fine workmanship, wear and resulting maintenance cost are minimum under the most rigorous service conditions.

Such a wide variety of types of "Shaw-Box" Mill Cranes have been built that designs requiring only slight changes to meet any specifications are already available. The result . . . lower initial investment for the finest in Mill Cranes.

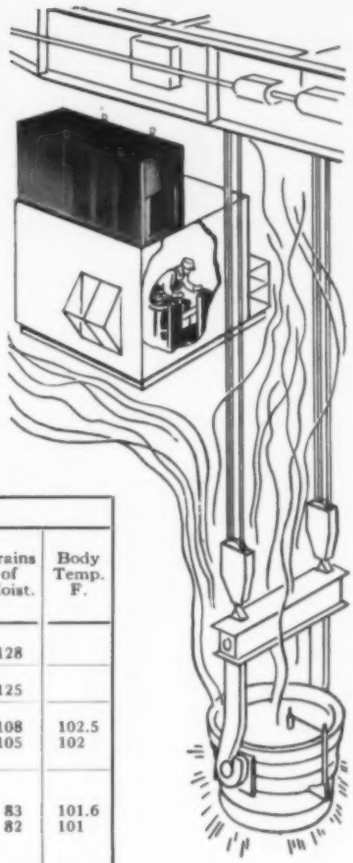
Be sure to send all your inquiries for Cranes and Soaking Pit Carriages to "Shaw-Box."

MANNING, MAXWELL & MOORE, INC.

SHAW-BOX CRANE & HOIST DIVISION

MUSKEGON, MICHIGAN

DRAVO CRANE CAB COOLERS



Dravo Crane Cab Coolers maintain comfortable working conditions and supply clean, pure air, under practically all atmospheric and temperature variations encountered in industry.

Not only is the health of the crane operator safeguarded but his alertness and efficiency are increased, with a consequent, substantial improvement in the overall safety and production of the department served.

Dravo Crane Cab Coolers are installed and operating on Soaking Pit, Ladle, Charging, Electric Furnace, Forge Shop, Stripper, Monocast, Reduction Plant, Fabricating Shop and Annealing cranes, and their effectiveness, dependability, and production-boosting ability have been convincingly demonstrated. Only electrical leads and connections are required for installation. Thermostat control—full automatic. Air is used for condensing.

OTHER FUNCTIONS INCLUDE:

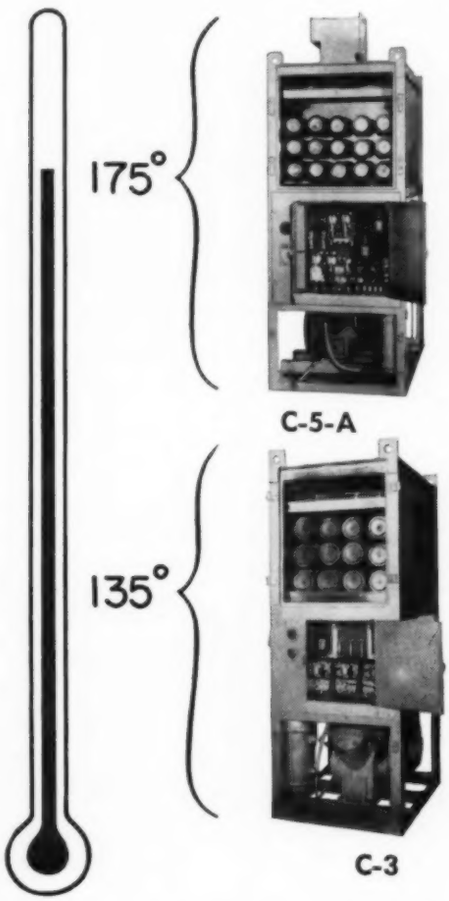
DUST AND DIRT REMOVAL. Make-up air passes through a wire mesh viscous type cleanable primary filter, is blended with return air, and the mixture is drawn through a similar secondary filter. This assures high dirt-removal efficiency.

FUME AND ODOR REMOVAL. Surfaces of activated carbon, proportioned to the capacities involved, remove almost every variety of fumes and gases ordinarily encountered in industrial operations. Tests show that CO, when present, is substantially diluted.

WINTER HEATING. Electric strip heaters are provided in sufficient quantity to temper the make-up air, and maintain 68 to 72°F in the crane cab during the normal winter heating season.

TEMPERATURE CONDITIONS

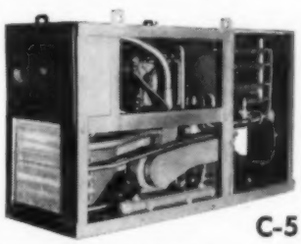
Type of Crane Operation	Amb. Temp. Dry bulb F.	Amb. Temp. Wet bulb F.	Relative Humidity %	Grains of Moist.	Body Temp. F.
Soaking Pit Coil Storage	160-170 164	94	7.8	128	
Ladle (open hearth pit side) Forging Furnaces	150-160 156	92	7	125	
Foundry (large castings) Charging (open hearth) Electric Furnace Cupola Charging	140-150 146 142	88 85	11 10	108 105	102.5 102
Ladle (small capacity) Pickling (over open vats) Aluminum Reduction Aluminum Remelting Copper Smelting Annealing Furnace	125-140 138 130	83 81	10 12	83 82	101.6 101
Cement Production Lead Production Glass Making Brass and Bronze Casting Steel and Iron Casting (small) Galvanizing Mill Vanadium Production Manganese Production	100-125 120	80	18	90	99.6



C-5-A

C-3

SUMMER COOLING. Hot weather generally creates the most difficult working conditions in crane cabs, and the cooling equipment has therefore been designed for top efficiency and maximum dependability. The temperatures ordinarily encountered in various operations are indicated on the chart. These temperatures determine the size of Dravo Crane Cab Cooler required.



C-5

DRAVO TYPE C-5 (Horizontal) and **C-5-A** (Vertical). These models are the same in capacity, and will maintain cab temperatures of 80 to 85°F when ambient temperatures range from 135 to 175°F. Two styles are offered, to meet installation space requirements. Motor hp: 5. O.D. Cabinet: C-5, 2'-6" x 6'-0" x 4'-0" H; C-5-A, 2'-7" x 3'-10" x 6'-0" H.

DRAVO TYPE C-3. Maintains cab temperatures of 80 to 85°F with ambient temperatures up to 130-135°F. Motor hp: 3. In borderline cases—the larger unit should be selected. O.D. Cabinet: 2'-2" x 2'-9" x 5'-6" H.

Dravo Crane Cab Cooler representatives are located in all principal cities. Write for the name of the one in your area.

DRAVO
CORPORATION
DRAVO BUILDING, PITTSBURGH 22, PA.

PITTSBURGH • PHILADELPHIA • CLEVELAND
NEW YORK • DETROIT • ATLANTA

DRAVO

WHY *QUIET* CRANES ARE BEST FOR STEEL MILL SERVICE

At the noise levels found in most steel mills, a few decibels more or less would be of little consequence were it not for the fact that NOISE IN A CRANE MEANS WEAR!

You will find that Whiting Cranes in steel mill service still run quietly after years of rugged use . . . ample evidence that they are well designed.

Let Whiting quote on your next crane, and design it to assure uninterrupted service. Whiting Corporation, 15655 Lathrop Ave., Harvey, Ill.

BUILDERS OF QUALITY CRANES FOR OVER 60 YEARS

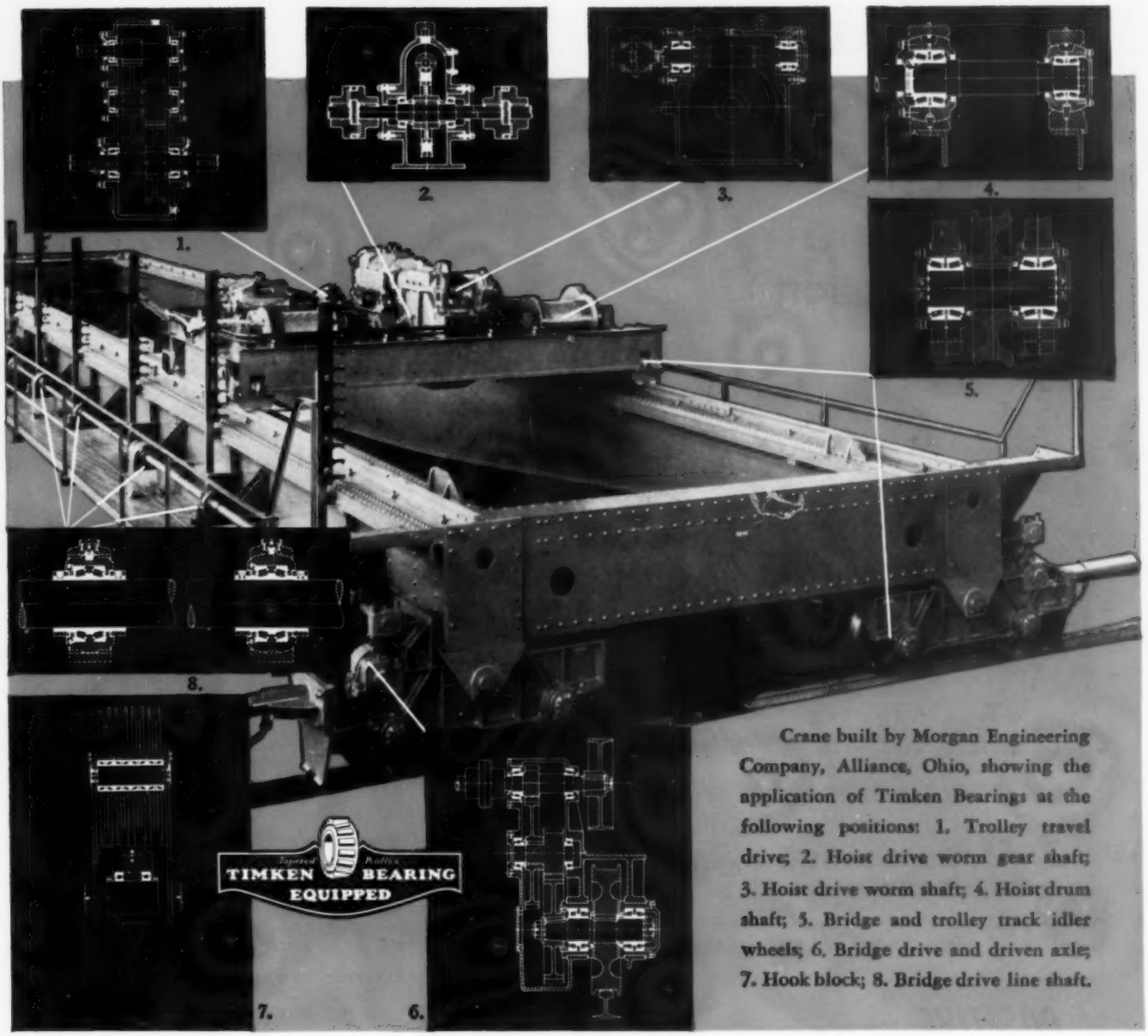
Dependable · · Quiet-Running · · Durable

WHITING

Overhead Traveling **CRANES**

Offices in Chicago, Cincinnati, Detroit, Los Angeles, New York, Philadelphia, Pittsburgh, and St. Louis. Agents in other principal cities. Canadian Subsidiary: Whiting Corporation (Canada) Ltd., Toronto, Ontario. Export Department: 30 Church St., New York 7, N. Y.

Keep 'em Traveling with TIMKEN BEARINGS



Crane built by Morgan Engineering Company, Alliance, Ohio, showing the application of Timken Bearings at the following positions: 1. Trolley travel drive; 2. Hoist drive worm gear shaft; 3. Hoist drive worm shaft; 4. Hoist drum shaft; 5. Bridge and trolley track idler wheels; 6. Bridge drive and driven axle; 7. Hook block; 8. Bridge drive line shaft.

A few Timken Bearings are better than none in any crane; even if you have them only in the bridge and trolley track wheels your cranes will perform better, last longer, cost less for upkeep.

In order to get the *full* benefits of Timken Tapered Roller Bearings however, you must have them *at every bearing position.* Then every moving part will be completely protected against friction; wear; radial, thrust and combined loads and misalignment. Then your cranes will consume less power; require less lubrication; operate faster; stand up longer; need less time out for maintenance.

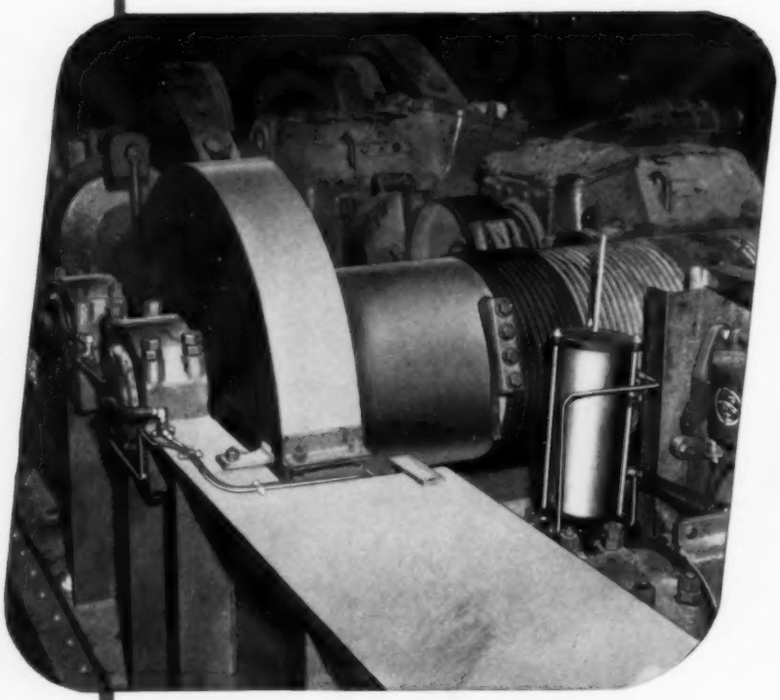
When buying overhead cranes of any size and capacity for any purpose, it will pay you to specify Timken Tapered Roller Bearings for all positions including those listed above. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◫ AND THRUST ⊣◫⊢ LOADS OR ANY COMBINATION ✳

NOW! Trabon GIVES YOU

Simple Positive **Automatic** Lubrication for *Crane Trolleys Crane Bridges*



Automatic 3400 Series Pumps can be driven from the drive shaft on the bridge or the drum or intermediate shaft on the trolley. They start and stop with the machinery. The more lifts—the more lubrication!

Check these Advantages of Trabon Automatic Crane Lubrication

- ✓ *SAFE*—Eliminates Hazardous Hand Lubrication
- ✓ *FAST*—No Down-Time for Manual Lubrication
- ✓ *POSITIVE*—No Skipped or Forgotten Bearings
- ✓ *SIMPLE*—Single Indicating Point at the Pump Tells the Whole Story —All-Hydraulic System is Sealed from Pump to Bearing

Mills in Ohio, Kentucky, Illinois and Pennsylvania have already installed Trabon Automatic Centralized Lubrication Systems on crane trolleys and bridges. The success of these automatic systems in eliminating the hazard of hand lubrication, in obtaining better bearing performance and in making the entire lubricating job simpler, easier and more positive is attested to by the repeat orders in plants where trial installations were made.

Write or call your nearest Trabon representative today for more information on these cost-reducing, trouble-eliminating lubricating systems.

Trabon ENGINEERING CORPORATION

1814 EAST 40TH STREET • CLEVELAND 3, OHIO

Centralized Oil and Grease Systems

CS-68

YOU CAN BE **SURE**.. IF IT'S

Westinghouse

Replacement costs go down when you use gears made of BP Gear Steel. That's because BP Gears are "taper-hardened" by an exclusive Westinghouse process.

First, Westinghouse carefully selects fine grain steel with specific metallurgical properties. Then, BP processing provides extremely-hard tooth surfaces to resist wear and assure long service life.

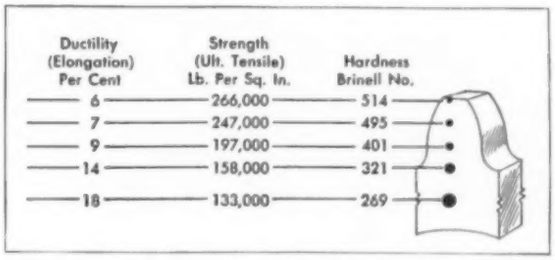
But it doesn't stop there. It's not just a surface "armor". The hardness tapers gradually from surface through the root of the gear tooth for maximum resistance to shock and overload.

Thus, you get the right combination you need for crane service . . . strength, toughness and high resistance to wear.

Gears made from BP Gear Steel cost no more than ordinary heat-treated gears—and deliveries are prompt.

Get the facts from your nearest Westinghouse office, or write for B-4395, "BP Gear Steel". Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa.

J-07281


Ductility (Elongation) Per Cent
Strength (Ult. Tensile) Lb. Per Sq. In.
Hardness Brinell No.
6 — 266,000 — 514
7 — 247,000 — 495
9 — 197,000 — 401
14 — 158,000 — 321
18 — 133,000 — 269

Westinghouse

GEARED DRIVES

Seek POWER TRANSMISSION *At Its Best*

AMERICAN

FLEXIBLE COUPLINGS

meet every test

TWO TYPES OF FLEXIBLE COUPLINGS—*All That Are Needed To Meet Every Service Condition.*

One coupling—the AMERICAN *Flexible Coupling* with full floating center member equipped with removable bearing strips transmits power under all variations common to low speed operation where a maximum degree of flexibility and protection against damage of equipment is required. Another coupling — the AMERIGEAR *Flexible Coupling* provides a means for gearing up for the direct transmission of power under all variations common to heavy duty and high speed operation where only a minor degree of flexibility is required. Thus, do these two types of flexible coupling meet all service conditions.

AMERIGEAR FLEXIBLE COUPLING

For high speeds or heavy-duty, gear up for direct, free and consistent transmission of power with Amerigear Flexible Couplings.

AMERICAN FLEXIBLE COUPLING

For low speeds, and a factor of greater protection against destructive damage to driven mechanisms, use American Flexible Couplings—the only couplings with a floating center member equipped with replaceable bearing strips.

AMERICAN FLEXIBLE COUPLING CO.

Affiliate of J. A. ZURN MFG. CO.

Over 20 Years of Power Transmission Experience

ERIE, PA., U. S. A.

Sales Offices in All Principal Cities of U. S. A.

AMERICAN FLEXIBLE COUPLING CO.
Dept. "S", Pittsburgh Avenue, Erie, Pa., U. S. A.
We Are Seeking Power Transmission At Its Best. Please send:
☐ Booklet "Relief from Bearing Wear Grief".
☐ American Flexible Couplings Catalog No. 481.
Name _____
Company _____
Address _____
Please attach to your business letterhead.

Announcing "NORMA" Stability-Tested GREASE

For General Purpose Bearing Lubrication

- ***CUTS BEARING LUBRICATION COSTS***
- ***INCREASES BEARING LIFE***
- ***ASSURES EFFICIENT BEARING OPERATION***

Users of ball and roller bearings can now obtain "Norma" Stability-Tested grease for all types of general purpose bearing lubrication.

Used for years in Norma-Hoffmann prepacked sealed bearings, "Norma" Stability-Tested grease has been giving excellent performance in all types of applications.

Outstanding advantages include —

High Resistance to Oxidation in storage and in service as proven by the well known Norma-Hoffmann Oxidation Bomb Test.

Insoluble in Water — will not emulsify or aerate in the presence of condensed moisture.

Protects Against Corrosion — Actual field tests in the Canal Zone prove its outstanding corrosion resistance.

Laboratory Tested—Each batch of grease is laboratory controlled to meet rigid specifications.

"Norma" Stability-Tested grease is available in tubes for easy bearing lubrication and in bulk for large quantity grease users. Keep your bearings operating at peak efficiency, use "Norma" Stability-Tested grease. Write for prices and information.

RUNNING TESTS FOR GREASE PERFORMANCE

The test units, illustrated, determine the lubricating properties of "Norma" Stability-Tested greases at elevated temperatures and under actual running conditions. Greases are tested in bearings operated at constant speed and temperature with regular cooling and starting cycles. Bearings are thrust loaded by springs. In other test units, bearings are loaded radially.

NORMA-HOFFMANN *Precision* **BEARINGS**

BALL • ROLLER • THRUST

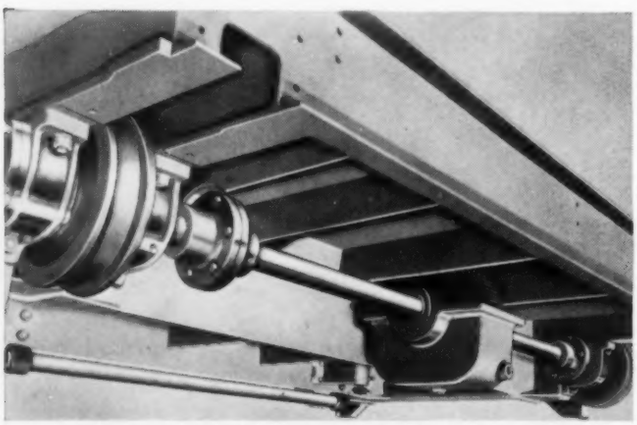
NORMA-HOFFMANN BEARINGS CORPORATION

Stamford, Connecticut

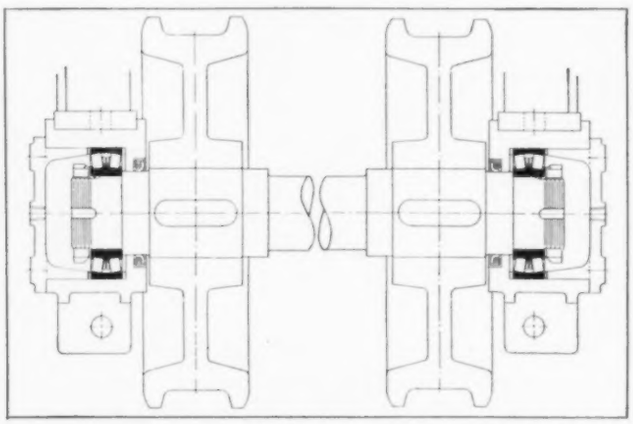
Field Offices: New York • Chicago • Cleveland • Detroit • Cincinnati • Los Angeles • San Francisco • Dallas • Seattle • Phoenix

Torrington Spherical Roller Bearings keep tons on the move in Harnischfeger Travelling Cranes

Steel Mill Overhead Cranes have to move tonnage rapidly and continuously. In P & H cranes, Harnischfeger Corporation, Milwaukee, Wisconsin, puts emphasis on rugged construction and long service life of all parts. In the trolley drive of the 10-ton crane above, Torrington Spherical Roller Bearings operate efficiently with minimum maintenance.



Close-Up of the trolley drive shows the pillow blocks that house the Spherical Roller Bearings. These bearings assure accurate shaft alignment without adjustment and are readily accessible for inspection and servicing.



Cross-Section shows the design incorporating Spherical Roller Bearings. When loads are heaviest, and shaft deflection most likely, these self-aligning bearings afford full roller contact area for sustained high capacity and free-rolling operation.

The high capacity of Torrington Spherical Roller Bearings, unimpaired by deflection or misalignment, can be applied to improve the operation and service life of your heavy-duty equipment. Our engineers will be glad to help you in adapting them to your designs. Write us today. THE TORRINGTON COMPANY, South Bend 21, Ind., or Torrington, Conn. District offices and distributors in principal cities of United States and Canada.

TORRINGTON SPHERICAL ROLLER **BEARINGS**

Spherical Roller • Tapered Roller • Straight Roller

Needle • Ball • Needle Rollers

Heppenstall
AUTOMATIC SAFE-T-TONGS

—cut handling costs
—save time *safely*

AUTOMATIC PICK-UP
As craneman starts the lift, tongs automatically grip the coil.

AUTOMATIC CARRY
Safe, sure, and fast! The heavier the load—the tighter the grip.

AUTOMATIC RELEASE
Coil deposited, release of weight allows tongs to lock open—ready for next pick-up.

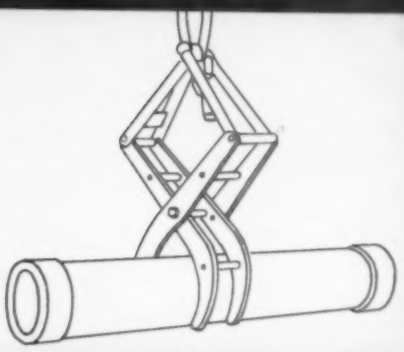
Adaptable to a wide variety of material handling applications, Heppenstall Safe-T-Tongs are fully automatic—not power driven. Attached to the hook of your crane or hoist, they replace chains or slings—reduce accidents—save manpower, time, and money.

If you have a repetitive handling problem, consider the efficiency of a Heppenstall Automatic Safe-T-Tong *engineered to your needs.* Heppenstall engineers will gladly cooperate in developing a type of tong to speed your work. Write today for your copy of our new Tong Booklet. Heppenstall Company, Pittsburgh 1, Pa.

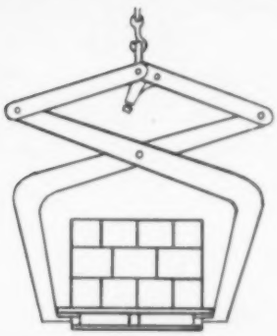
60TH ANNIVERSARY 1889 1949

HEPPENSTALL COMPANY

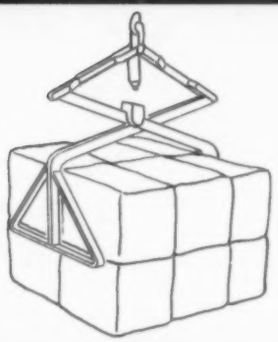
Pittsburgh Bridgeport Detroit



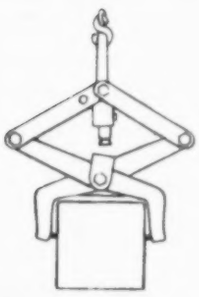
. . . FOR PIPES OR BARS



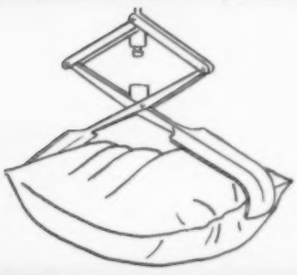
. . . FOR PALLETS



. . . FOR BALES



. . . FOR RECTANGULAR SHAPES

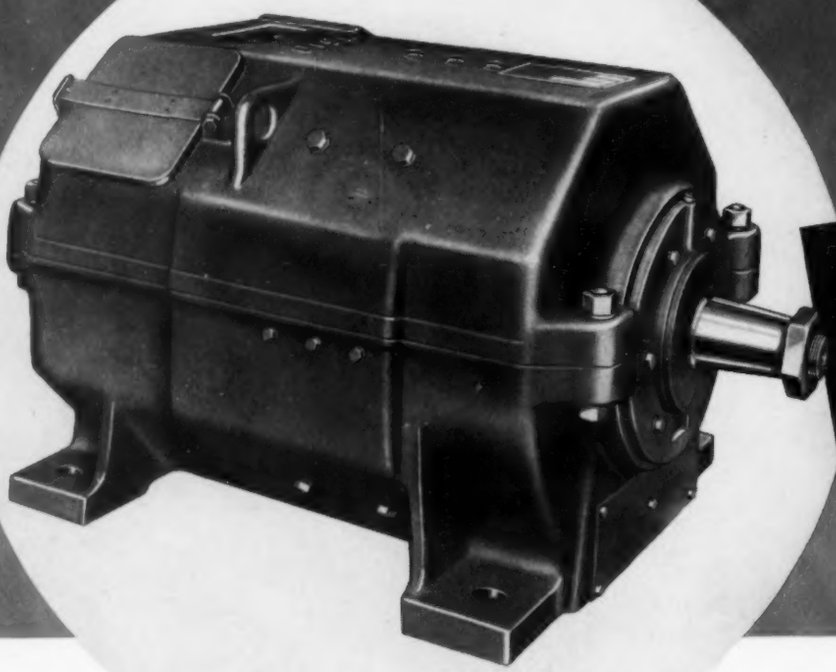


. . . FOR SACKS

NOW READY!

The New CROCKER-WHEELER FORM W 600 SERIES AUXILIARY MILL MOTOR

For Heavy Duty Mill and Crane Service



BUILT TO THE STEEL INDUSTRY'S SPECIFICATIONS!

Here's the mill motor the steel industry wanted. This new improved Form W 600 Series by Crocker-Wheeler is built to A.I.S.E. Standard No. 1. And it's available now!

More active material is provided in the same amount of space. Better utilization of existing space increases horsepower without adding to frame size.

Steel men said they wanted accessibility for motor servicing. Note, in the illustration above, how easy it is to get at all motor parts. And this is merely one of many new features Crocker-Wheeler has built into its new Form W 600 Series motors.

Crocker-Wheeler engineers are accredited specialists in building motors for cranes and heavy auxiliaries in steel mills. C-W designed the first mill type motor as far back as 1905, and has been making motor news in the steel industry ever since.

Find out more about the new Crocker-Wheeler Auxiliary Mill Motors—their greater efficiency, ease of maintenance and other unique advantages. Send today for Bulletin. Write Crocker-Wheeler Electric Mfg. Co., Ampere 3, N. J.

✓ CHECK THESE LOW MAINTENANCE — LONG-LIFE FEATURES

FIELD COILS Wound on mold over mica cell. Mica-washers at top and bottom of coil. Glass tape applied over cell, washers, and coil. Coil is filled layer by layer, during winding, with insulating compound that resists high temperatures, moisture, and oil, and provides an extremely homogeneous structure.

ARMATURE COILS Conductors are silicone-bonded, double-glass-covered wire. Slot portion of coil insulated with 4¼ layers of glass-backed mica wrapper lapping with layers of glass-backed mica tape which extend around the coil bends and nose for reinforcement. Entire coil taped with closely woven glass tape.

INTERNAL CIRCULATION Integrally-cast fan blades on rear coil support circulate air through core ducts and between field coils, dissipating heat to frame. Provision is also made for forced ventilation.

GET COMPLETE DETAILS of these and many other reasons why the new Crocker-Wheeler Form W 600 series is your best buy in mill motors. Ask for Bulletin SL-620-1.

CROCKER WHEELER

ELECTRIC MANUFACTURING COMPANY, AMPERE 3, N. J.

Division of Joshua Hendy Corporation

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IF CROCKER-WHEELER BUILDS IT IT'S A BETTER-BUILT MACHINE

"TOOL STEEL" PROCESS

TRACK WHEELS FOR OVERHEAD CRANES...

provide

YEARS OF SERVICE AS COMPARED TO MONTHS FOR OTHER MATERIALS!

"Tool Steel" track wheels are providing up to 30 times the life of ordinary wheels used in the same service!

This amazing superiority is substantiated by our customers' own records.

Investigate these facts today. You'll find the same unequalled quality built into other "Tool Steel" parts for cranes, including gears, pinions, brake and sheave wheels, axles and sheave pins!

WE GUARANTEE our products to give sufficient life over any other grade of hardened material operating in the same service to cover any difference in first cost. If our material fails to fulfill this guarantee, we will make good the deficiency in either cash or new material.

THIS GUARANTEE WAS ORIGINATED BY AND IS EXCLUSIVE WITH THE TOOL STEEL GEAR AND PINION CO.

HERE'S AN ACTUAL COMPARISON:

(From the customer's own records:)

WHEELS	AVERAGE LIFE IN MONTHS
High carbon cast	8 to 12
Manganese steel	12 to 18
Hardened rolled steel	16 to 20
"TOOL STEEL"	**over 168***

*After **14 YEARS** of service further records were deemed unnecessary.

This service life can be equalled by no other products!

Write today for complete information.

"TOOL STEEL" PROCESS

The Standard of Quality

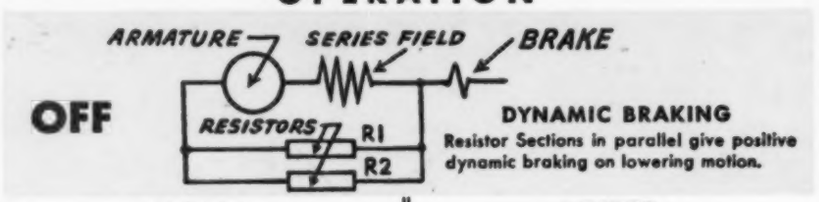
for GEARS • PINIONS • ROLLS • WHEELS *and other* HARDENED PRODUCTS

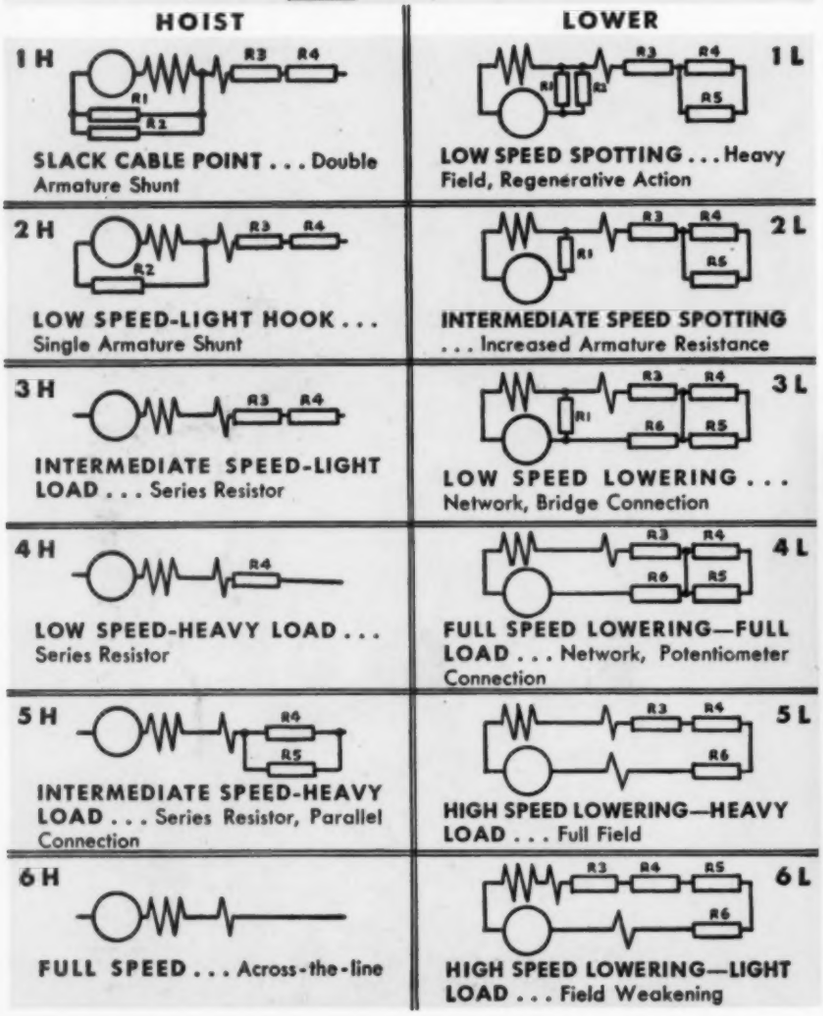
THE TOOL STEEL GEAR & PINION CO.

CINCINNATI 16, OHIO, U. S. A.

New DYNAMIC LOWERING NETWORK SYSTEM FOR HOIST CONTROL

OPERATION



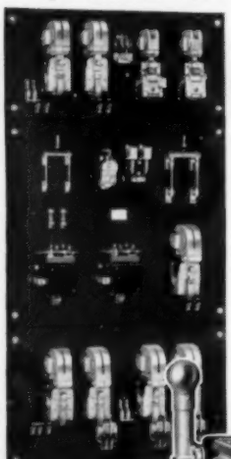

HOIST
LOWER
1 H
1 L
R1
R2
R3
R4
R5
SLACK CABLE POINT . . . Double Armature Shunt
LOW SPEED SPOTTING . . . Heavy Field, Regenerative Action
2 H
2 L
LOW SPEED-LIGHT HOOK . . . Single Armature Shunt
INTERMEDIATE SPEED SPOTTING . . . Increased Armature Resistance
3 H
3 L
R6
INTERMEDIATE SPEED-LIGHT LOAD . . . Series Resistor
LOW SPEED LOWERING . . . Network, Bridge Connection
4 H
4 L
LOW SPEED-HEAVY LOAD . . . Series Resistor
FULL SPEED LOWERING—FULL LOAD . . . Network, Potentiometer Connection
5 H
5 L
INTERMEDIATE SPEED-HEAVY LOAD . . . Series Resistor, Parallel Connection
HIGH SPEED LOWERING—HEAVY LOAD . . . Full Field
6 H
6 L
FULL SPEED . . . Across-the-line
HIGH SPEED LOWERING—LIGHT LOAD . . . Field Weakening

Safer. Two spring closed contactors and resistor sections in parallel insure positive dynamic braking on lowering motion.

More Control over hook. Double armature shunt makes slack cable and low speed—light hook points individually adjustable. Series relay provides for high speed lowering of heavy load with full field stability, and yet permits field weakening necessary for high speed lowering of light loads.

Reduced Maintenance. Network circuit is designed for low current peaks during motor acceleration. Maintenance is minimized on control contactors as well as on motor commutator and brushes. Only nine contactors are required for control system.

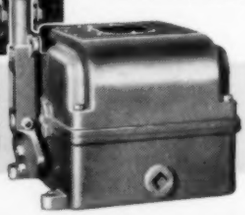
Less Space for resistors. Network system is designed for maximum use of resistor sections, and reserve capacity can be provided within reasonable dimensions.



Class 7954 Dynamic Lowering Hoist Control Panel

Only nine contactors are needed to give better hook control with the new network system.

Write for descriptive Bulletin 7954. Square D Company, 4041 N. Richards Street, Milwaukee 12, Wis.



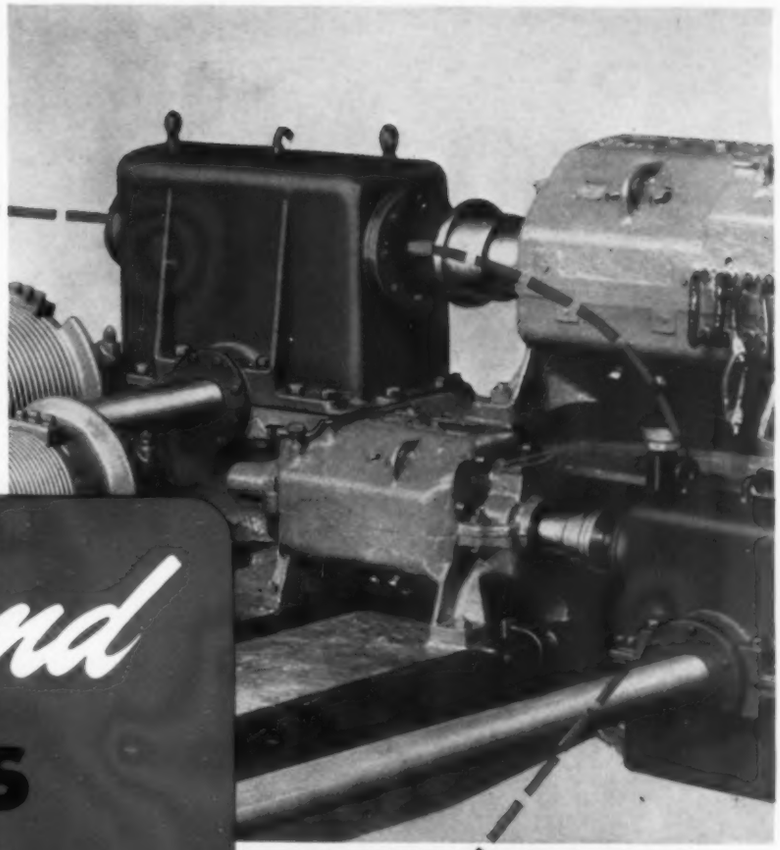
CLASS 9003 MASTER SWITCH

SQUARE D COMPANY

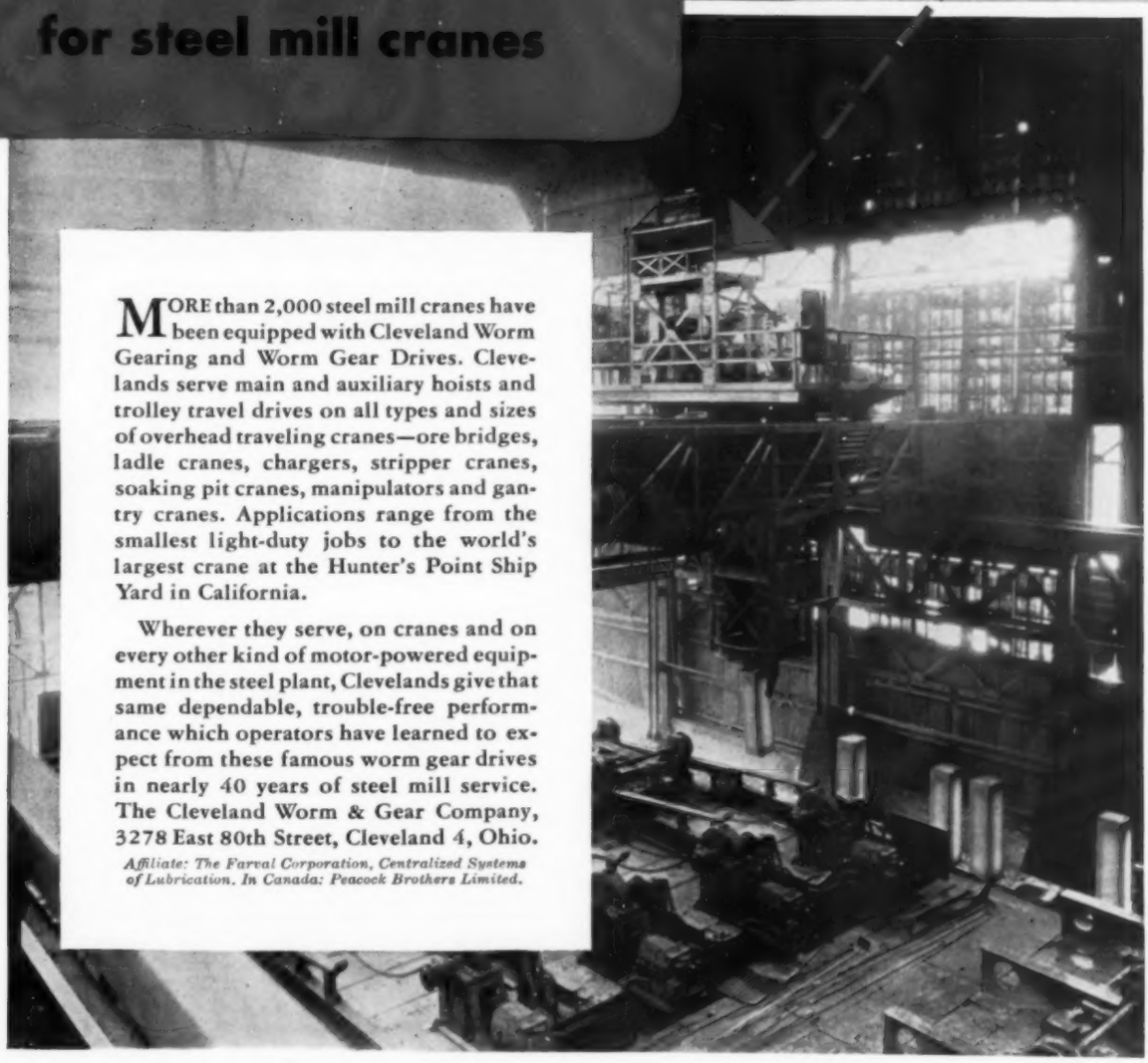
DETROIT • MILWAUKEE • LOS ANGELES

SQUARE D COMPANY CANADA LTD., TORONTO • SQUARE D de MEXICO, S.A., MEXICO CITY, D.F.

One of the 3 Clevelands on the trolley of an overhead crane.



Cleveland drives for steel mill cranes

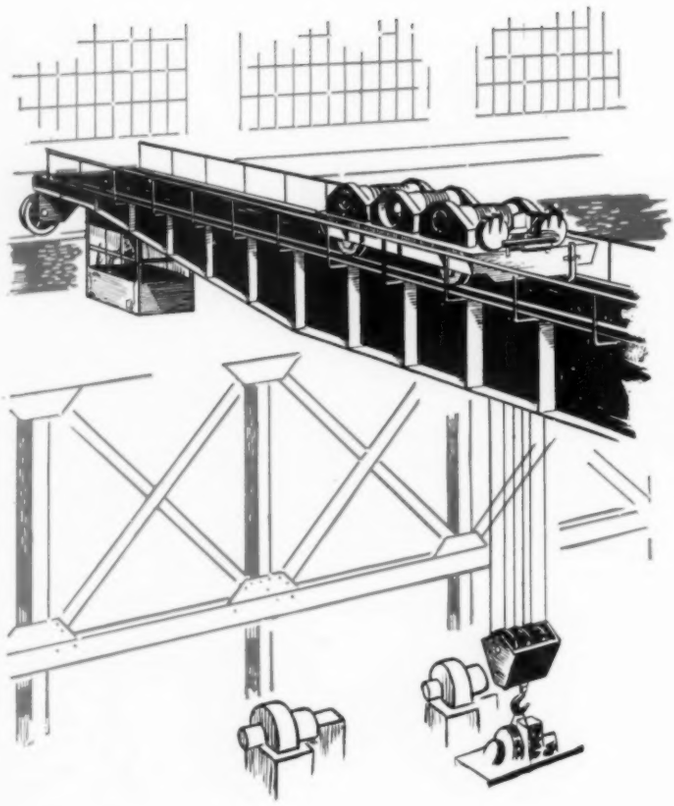


MORE than 2,000 steel mill cranes have been equipped with Cleveland Worm Gearing and Worm Gear Drives. Clevelands serve main and auxiliary hoists and trolley travel drives on all types and sizes of overhead traveling cranes—ore bridges, ladle cranes, chargers, stripper cranes, soaking pit cranes, manipulators and gantry cranes. Applications range from the smallest light-duty jobs to the world's largest crane at the Hunter's Point Ship Yard in California.

Wherever they serve, on cranes and on every other kind of motor-powered equipment in the steel plant, Clevelands give that same dependable, trouble-free performance which operators have learned to expect from these famous worm gear drives in nearly 40 years of steel mill service. The Cleveland Worm & Gear Company, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

FOR 19 YEARS
never a bearing failure with Farval



NINETEEN years ago, Farval Centralized Lubrication was installed on a 10-ton overhead traveling crane in one of the steel mills in the Chicago district. A recent report on this early job states that the Farval systems are still in service, as good as on the day they were installed, and that since 1930 the crane has never been down for a bearing repair or replacement. In short, there has never been a minute's trouble due to faulty lubrication.

Two manually-operated Farval systems—one on the bridge and one on the trolley—serve 56 points of lubrication including the wheel bearings. In less than five minutes, every eight hours, the operator lubricates every bearing on the crane from two conveniently located hand pumps. No need to climb all over the crane and never a bearing is skipped. Grease consumption is greatly reduced because there is no waste, and drippage is practically eliminated.

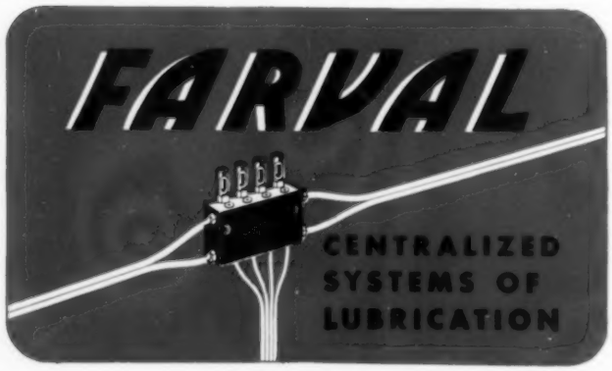
More than 2000 Farval systems have been installed on cranes. Many of them are roller bearing cranes, where clean grease is essential and over-lubrication should be avoided.

Farval has proven itself in over 20 years of service. It is the original Dualine system of centralized lubrication that others imitate. The Farval valve has only 2 moving parts—is simple, sure and foolproof, without springs, ball-checks or pinhole ports to cause trouble. Through its wide valve ports and full hydraulic operation, Farval unfailingly delivers grease or oil to each bearing—as much as you want, exactly measured—as often as desired. Indicators at every bearing show that each valve has functioned. For a full description, write for Bulletin No. 25.

The Farval Corp., 3278 E. 80th St., Cleveland 4, O.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

FARVAL—*Studies in Centralized Lubrication* No. 106



WATER WORKS MAINTENANCE

By GEORGE H. DANN
Engineer and General Supt.
Philadelphia Suburban Water Co.
Bryn Mawr, Pa.

. . . . it is not only possible to locate underground pipe lines without uncovering them, it is also possible to locate details of the line, and what may be more important, leaks . . . .

▲ HISTORICALLY, public water supplies in the United States date from "about 1732" at Schaefferstown, Pa., 1761 at Bethlehem, Pa., and 1652 at Boston. The Bethlehem works, which included the first American pumps, were begun in 1754 and finished in 1761, "after severe struggles," by Hans Christiansen, a millwright and native of Denmark—the first water-supply engineer on record in America. At the close of 1800, there were seventeen water works in the United States. This number did not double until 1825 and did not pass the hundred mark until 1850. As late as 1875 there were but 243 works in the whole United States. Then rapid growth began. The thousand mark was passed in 1885. Nearly a thousand works were built in each of the next two half-decades, making about 3,000 works in 1895.

From 1895 to 1940, water systems advanced so rapidly in numbers and magnitude that no private agency was able to maintain a census. As of 1940, the U. S. Public Health Service made a nation-wide collection of data from the various states and published it as a report on "Public Water Supply" early in 1944.

Until 1870 there were no water filtration plants in the United States, as the term is now understood, but some of the surface supplies then in use were passed through so-called filters or strainers of gravel, charcoal or sponge. In 1870 Poughkeepsie, and in 1874-75 Hudson, N. Y., built slow sand filters of the English type which stood alone in the United States until modified slow sand filters were built in Lawrence, Mass., in 1893. Meanwhile, in the late 80's the earliest rapid or mechanical filters were built. In 1897 there were about 100 rapid, but only a dozen or so slow sand filters in use on public water supplies in America. In 1925 there were about 587 rapid and about 47 slow sand filters in use, with a total capacity of approximately 5,000,000,000 gallons per day.

Presented before AISE Annual Convention, Cleveland, Ohio, September 29, 1948

In 1940, there were 5,372 water treatment plants of all types in the United States producing over 7,000,000,000 gallons of safe water every day. Chlorine treatment of water (first used in 1908) was practiced in 4,590 systems; softening in 547, iron or manganese removal in 598 in 1940. More than 1,400 plants added some type of treatment intended to improve the taste or odor of the supply. Today an average of less than one person per year in 100,000 living in American cities dies of typhoid fever. This disorder at the turn of the century was thought of as a "water-borne" disease and nearly two hundred deaths occurred annually where but one occurs today. Modern sanitation along with adequate protection of water supply is responsible for this.

Many water systems are in need of maintenance; in fact, maintenance should start the day the water system is placed in service. The original operating conditions should be catalogued for later comparisons. The various losses of head on the pipe lines should be indicated and the daily and hourly water use should be noted.

LEAK SURVEYS — PIPE LOCATION

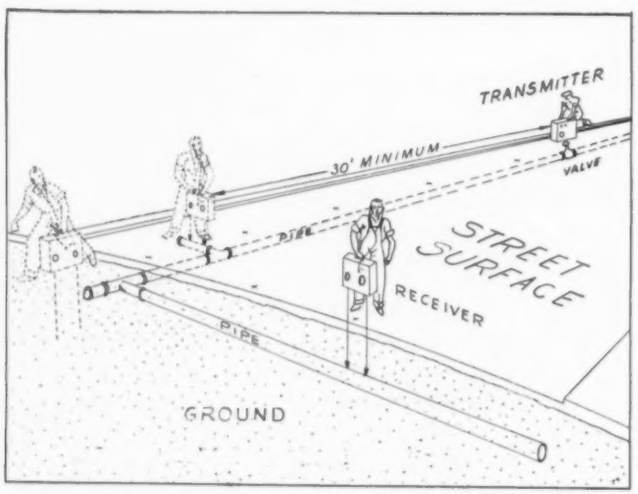
Immediately after placing a water system in service, a method of checking leakage should be established. In days past, when there was an abundant supply of water and the demand for this water was small, no thought was given to the saving in both supply and pumping costs by locating and repairing leaks that might exist on any particular distribution system. However, as the population increased, with the resultant increase in water consumption and as this increased consumption made a demand on the resources, along with mounting pumping costs, the water works industry as a whole, and the smaller operators in particular, decided that something should be done about this question.

Although there have been many advances in other scientific fields of research, the lowly leak survey in the minds of many operators is still a mystery. To many of these men, who are very efficient operators, a leak is something that eventually shows up on the surface of a road or street and then you dig down where the water shows and if you are lucky you find a leak. If not, you dig some more holes. However, with the advent of concrete surfaced roads, the leak surveying problem increased by leaps and bounds, for the water did not appear immediately above the leak but sometimes even a whole block away, and in cases ran into a sewer or creek and never appeared to give the operator his cue.

The first step for a water works engineer to take in attacking this increasingly important question is to know your system. That is, if you do not have a complete map showing all the piping in your system and its relative location, this should be your first job. You may well say that this is easier said than done, but in these days when the market carries a number of pipe locators that have produced a very efficient operation, it can be done and the cost is not prohibitive. Explaining the general operation of a pipe locating instrument, it consists of a modulated transmitter working on a frequency of 175 kilocycles, modulated with an audio-frequency of 1000 cycles. Self-modulation is used and the two type 31 power tubes employed in the transmitter are oscillating simultaneously on the above two frequencies. No special modulating tube is installed. This simplifies the circuits greatly and only makes it necessary to balance the instrument for one frequency. The power of the transmitter can be regulated by means of a power switch which reduces the plate voltage of the transmitter from 45 volts to 22½ volts. The B-battery drain of the transmitter on high is 0.5 mill. With the power switch on low it is 0.25 mill. The output of the transmitters is connected to a balanced loop-circuit.

The receiver consists of a two-stage impedance coupled radio-frequency amplification detector and two stages of audio amplification. The phones can be connected to either the first or second audio-stage by means of a selector switch. The second audio-stage is connected to a tube voltmeter which will read about 0.9 mill with no incoming signal. When a signal is received the reading will drop as low as 0.1. The procedure of having the meter read backward is important, as it will not allow a strong signal to bend the needle of the meter or damage the meter otherwise. A balanced loop is likewise coupled to the input of the receiver. The B-battery drain is 10 mill.

Figure 1 — The method used to locate pipe employs a principle similar to that of a mine detector.



In order to make a complete survey of your underground piping, it is only necessary to have the knowledge of one known point on any of your underground interconnected piping. By then taking a layout plan of your property, whether a public system or a private plant, and placing the sending unit at the known point, the receiving unit is then placed at a distance from the sending unit of at least 30 ft on an arc. When the receiving unit crosses the pipe carrying the radio beam, a maximum sound is heard in the earphones and a low reading is indicated on the visual meter. At that time both units are directly over the pipe. By drawing a line beneath the first instrument and through the second instrument, a line of the pipe can be plotted and by following this same method the whole underground piping system can be charted as to location, as to depth of pipe, and as to actual outside diameter. After locating the exact center of your pipe by carrying the receiver in a vertical position and securing the maximum signal, and then by turning the receiver in a horizontal position until you get a null, then moving out over the pipe and starting at this point and moving away from the pipe at a 90 degree angle until the null position is again found, keeping the receiver at a 45 degree angle with an edge of the box on the ground when this null position is found, the depth of the piping below the surface of the ground will be the same distance as that of a horizontal line from the center of the receiver box to a point directly above the spot previously marked on the surface of the ground minus the perpendicular distance from the center of the receiver box to the surface of the ground. See Figure 2.

These facts to the water works operator seem to be a kind of mystical performance. It has been the experience of the writer on many occasions when these instruments first came into being, to endeavor to locate some long lost and forgotten pipe line. When the machine indicated the pipe to be in a certain location, the local water works man or the sidewalk superintendent would say how wrong the machine was and of what little value. When the location as indicated by the machine was excavated and there lay the pipe not only in the location as noted but also at the depth and the size that was indicated, it seemed to be some kind of magic to them. After the system has been completely mapped, the next step to determine is the hourly use into the distribution system of the plant. In most cases, this is measured on meters. When the day rate and the night rate are determined, an experienced water works engineer can immediately determine the ratio between the night rate and the day rate and can reach a conclusion as to the requirements for a leak survey. This night rate on a system or a plant that works only through the daylight hours, is a wonderful barometer of the system's conditions, as the use or consumption usually diminishes during the early morning hours. Leaks do not have the courtesy to stop no matter what time of the day or night it happens to be. If during the period of

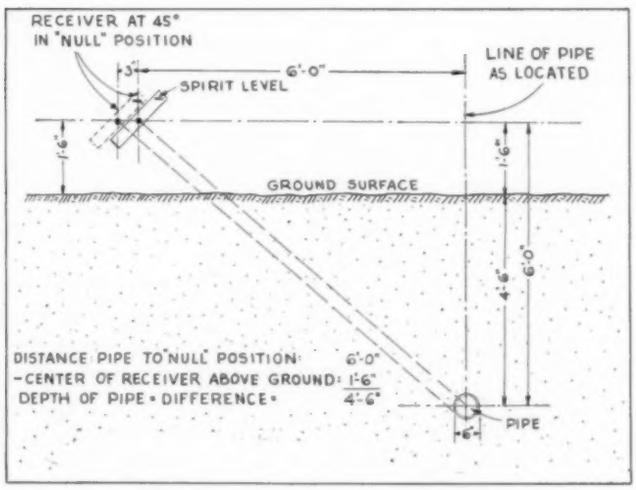
minimum use a high rate shows, this would indicate a high rate of leakage.

There have been a number of methods advanced for leak surveys. One method is to start at the source of supply and add a segment of piping from valve to valve, after which any increase in flow is noted on measuring the input to the system. By this method any large increase through a portion of the distribution system not having a large known demand would indicate consumption other than use. There is another method which has been used with great success recently; that is, the day rate and the night rate are noted and compared and then by means of an electronic leak locator that amplifies vibrations given off by water leaving a pipe and by filtering out other vibrations that are not in the same wave band, it is possible to determine the location of leaks. From experience extending over a number of years, it has been found that even a slight hiss on a caulked joint or a corresponding leak at a thread on a threaded pipe is easily discernible. There is a very definite saving in the cost of locating leaks by using this type locator, as in many places the leak is covered by expensive paving or flooring. When this machine is used, instead of excavating a number of holes, in most cases the leak is found in one opening.

LOSS OF HEAD TESTS

In addition to the leak survey problem, the water works operator finds himself up against the problem of explaining away the reason why a 6 in. main on First Ave. or in "B" Section of his plant does not seem to carry as much water as it did formerly. By means of loss of head tests it is possible to determine where the bottlenecks or pressure losses are in your plant. All that is required is a measuring device, whether it is a pitometer rod or a regular water meter, to determine the flow in any pipe line within your distribution system or plant, and then two pressure gauges attached to this line at a known distance apart and at an elevation that is correlated. By means of these simple tests, a hydraulic slope can be plotted which will clearly indicate where your abnormal losses occur, which can be a partly closed valve, corroded fittings, undersized pipe and various other maladies common to the plant engineer or water works superintendent.

Figure 2 — Not only can pipe be located but the depth below the surface of the ground can be determined.



It is possible with a pitometer rod and a U-tube containing liquid of a known specific gravity to explore the interior of a pipe line and draw a graph known as a traverse, showing on which quadrant surface rust encrustations have adhered to the interior of the pipe line. This again is a service that is invaluable to the water works operator in determining the condition of his piping.

When by means of a traverse it is found that a pipe line has a coefficient which is such that it definitely shows that the pipe has lost a sizable amount of its carrying capacity due to these rust encrustations it is wise and economical to clean this pipe at a small portion of the original cost of installation and restore its carrying capacity to its former proportions. However, it has been known by engineers for some time that subsequent to cleaning of water pipe, the rate of corrosion has increased due to the fact that any pipe, no matter how badly it may be corroded, has a certain percentage of the original coating remaining. However, when this pipe is cleaned it is bound to remove a certain portion of this coating. Therefore, it is easily seen that if a pipe is cleaned and then exposed again to the action that causes oxidation without the benefit of this original coating, there would be a more rapid rate of oxidation.

CLEANING AND COATING PIPE

In recent years, it has been found feasible to not only clean the pipes but to coat pipes. There are a number of different types of coating on the market and they all have their advantages. The English have been cleaning tuberculated cast iron pipe since 1866 and it has been the general practice in the United States for forty years. However, the coating has only been in use in recent years. In some cases, these coatings consist of cement lining which is placed inside the pipes after they have been thoroughly cleaned.

There is another type of coating that is of a bitumastic character and is electroplated, so to speak, on the inside of a pipe line. It has been found economically feasible with the increase in cost of materials, especially pipe, labor and also because of the permanent surface that has to be broken, to replace these pipes to maintain the piping system that now exists rather than follow the pattern of years past, where, if and when a pipe had lost capacity a new pipe line or section was the answer. Water works engineers in making tests before and after the renovating of old pipes have found that in many cases the renovated pipe line after being cleaned and coated approximates the coefficient of new pipe. We understand that 500 to 1000 ft can be coated in place and the pipe line is only out of service for a portion of a day. We will not go further into this subject but we believe that as the increased costs mount, we will more and more have to maintain to a high degree of efficiency those facilities which we have.

PIPE SIZING

While we are on the question of renovating old pipe

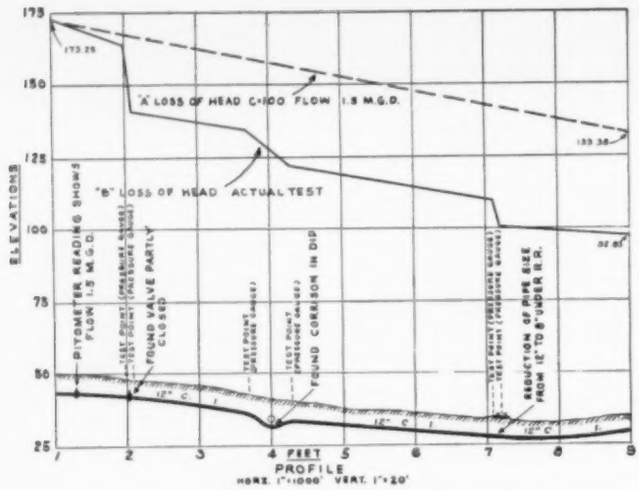


Figure 3 — It is also advisable to test for loss of head as this may sometimes indicate bad pipe conditions.

lines, it might be called to the attention of the water works man, especially the plant engineer, that when a pipe needs attention and if it is determined to replace it with a new pipe, due consideration be given to the proper sizing. It has been the experience of many water works men in cases of complaints from industrial plants that inspections show that the pipe system of these plants has grown just like "Topsy." That is, due to increased personnel, more showers were required in building "F." The workmen come to install the necessary piping and find the nearest water pipe and attach to this pipe for a supply. In many cases, the new piping has been properly sized, but it has been found that many times a 3 in. line if traced back to its supply, connects on to a 1 or 1½ in. supply line. With this in view, we believe that it is important not only to size a pipe correctly in the new installation, but before making additions, determine what the original supply to this new installation can be expected to produce, and in sizing, consider not only the present requirements but also the ultimate requirements going to be placed on the pipe line during its period of service.

LEAK REPAIRING

When a pipe is to be repaired whether this is caused by a leak or some other reason, and whether the leak occurred in the public water supply or an industrial plant, the essential thing to be considered is usually the speed in which the repair crew can repair the broken line and resume service. In cases of cast iron pipe where the mains are cracked around the circumference, which so often happens, it has been found that a mechanical repair clamp can be placed over the break, in many cases without shutting down. If the crack in the main has not distorted to any great degree the alinement of the two sections of pipe, often these mechanical clamps are placed around the pipe to one side of the broken section and bolted loosely in place. Then they are slid down across the broken section and the bolts are tightened without the necessity of shutting down. In case of leaks in pipe lines of bell and spigot type where the leak is at the bell of the pipe, a bell repair sleeve can be placed over the broken section and the water can be drained out through a 2 in. drain plug in the bottom of the repair sleeve. When the clamp has been attached to the pipe line and tightened in place, the 2 in. plug is then inserted in the bottom of the sleeve and the leak is repaired without interruption of service. In case of leaks on other types of pipe, it has been found that mechanical sleeves or repair clamps have cut down by many times the out of service time caused by water main breaks.

STANDPIPE PAINTING

Steel water tanks should receive careful annual inspection. On these inspections, if you do not have a man in your organization who you feel is qualified to make these annual inspections, the leading designers, fabricators and erectors of steel water tanks are in a position to offer inspection service.

Paint has been and still is a proven method for protection of steel. Even the best paints will not adhere to rust and without the steel having been properly brushed. This is all that is really necessary, unless the steel surface is badly corroded, when more severe methods may be required such as sand blasting. The ideal time to clean and repaint is during the early spring and late fall months and never when temperatures are likely to be less than 50 F, with the ideal condition being from 60 to 70 F.

The use of good paint is a real economy since labor is a great factor in the cost of painting, amounting to approximately 80 per cent of the total cost. The use of a better grade of paint adds little to the final cost. There are many top flight paints on the market that will give good results.

It has been the judgment of many water works men to paint the outside of the standpipe and to hot-coat with a bitumastic material the inside of the standpipe. Experience with various types of water and local conditions dictate the length of time that a coat of paint or hot-coating will stay in first class condition. The average time interval between the painting and coating operation is usually five to seven years. In lieu of frequent painting, you may have installed in your tank cathodic protection units. These units are usually of the sacrificial anode type and it is claimed they will maintain the coating in good condition. This method to a great degree is still in the experimental stage, although there are many actual installations that are producing good results.

ELECTROLYSIS AND CORROSION

There have been many articles written on electrolysis and corrosion. Reference to these articles in search of the solution to a corrosion problem have often confused engineers and in many cases the remedial measures decided upon have not solved the problem. The reason for this is that corrosion of a structure may appear to be due to one cause when actually the corrosion is due to more than one cause.

Electrolysis or corrosion of structures often takes quite a few years to become apparent because the corrosions occur in an environment where the structure is actually not visible for daily observation. That is, a pipe buried in the ground is not known to be corroding until loss of the product carried by the pipe indicates that a "rust-out" has occurred. Likewise, corrosion of valves, pumps, condensers and the inside of water storage tanks generally is not discovered until serious pitting has developed. If the pipe, valve, pump, etc., were visible for frequent observation, management would readily agree that something should be done at once, when they saw the deep pits developing. But since the corrosion occurs insidiously, no one is concerned until the failure actually occurs. In other words, one might apply "out of sight—out of mind" to most structures subject to corrosion.

Every case of serious corrosion may have more than one cause, and practically every case of corrosion is different and requires different treatment for its elimination. So no definite rule can be laid down to prevent all cases of corrosion. However, if tests are properly made to determine the exact causes of corrosion failure, further corrosion can be absolutely eliminated by the application of the proper remedial measures.

Electrolysis is generally applied to corrosion due to stray railway current. Either the elimination of the stray current by the use of properly installed insulating joints, or the removal of the stray current by electrical drainage will eliminate corrosion due to electrolysis. The success or failure of either methods is due to the proper or improper selection of the method. For example, the installation of insulating joints at the proper locations with due regard for the "shunting" effect of the environment (earth, water, etc.) will prevent the flow of stray current and avoid electrolysis. The improper selection of the locations for insulating joints will increase corrosion failures. Also, the application of electrical drainage will eliminate corrosion of the structure if properly designed. If applied to a structure with resistance joints, such as couplings (even screw couplings), the method will cause serious corrosion at other points.

Figure 4 — The 4-in. joint leak shown was found by the leak detector and there was no evidence of any leak on the surface of the ground.

Sulphate reducing bacteria cause very serious corrosion. This process is generally referred to as microbiological anaerobic corrosion. In this process the anaerobic bacteria (bivrio desulfuricans) reduce the sulphates in the environment to the sulphides. These bacteria being anaerobic (deficient oxygen environment) are not active in the presence of free oxygen. However, they need metallic oxygen for their growth. They obtain this oxygen from the sulphate by using iron pipe, for example, as the hydrogen donor in the process. The laymen may think of this process as the pipe being subject to the formation of small drops of sulphuric acid at the pipe surface which is immediately neutralized. The environment, therefore, actually remains about neutral with respect to pH. For the electro-chemist the actual reactions have been written:

$8H_2O \rightleftarrows 8H^+ + 8(OH)^-$ Anodic solution of Fe

$4Fe + 8H^+ \rightleftarrows 4Fe^{++} + 8H$

$H_2SO_4 + 8H \rightarrow H_2S + 4H_2O$ Cathodic depolarization

$Fe^{++} + H_2S \rightleftarrows FeS + 2H^+$ — Ferrous sulphide

$3Fe^{++} + 6(OH) \rightleftarrows 3Fe(OH)_2$ — Ferrous hydroxide

This complete process may be expressed in one equation as follows:

$4Fe + H_2SO_4 + 2H_2O \rightarrow 3Fe(OH)_2 + FeS$

The actions above mentioned occur most frequently in clay soils, marshes, pipe buried deep in the soil, (where the oxygen supply is deficient) the bottom of iron, water or gasoline or fuel oil tanks, or inside water cooler pipes, etc., or water storage tanks, or on the inside of condenser tubes through which river water high in organic material is flowing. In the latter case, chlorination of the river water usually helps. The complete protection for this form of corrosion varies due to actual conditions and is quite complicated. Only an experienced man should decide whether the remedy is chlorination, oil treatment, cathodic protection, encasing in pitch, etc.

The remedy for this form of corrosion is to keep the moisture (not necessarily free water) from contacting the structure. Since all forms of pipe coatings, or coatings for the inside of water storage tanks, will develop what are called "pin-holes" with time, their use will be found satisfactory only when supplemented with cathodic protection.

Mr. Raymond F. Hadley of the Susquehanna Pipe Line Co. of Philadelphia has done considerable work on microbiological anaerobic corrosion and is the best

authority on this form of corrosion. An excellent reference to his work will be found in the Electrochemical Society's Handbook on Corrosion which has just been published.

Differential aeration causes very serious corrosion of all metals in an electrolyte (earth, water, etc.). In this process the structure at one point may have a lesser amount of oxygen available at the surface of the structure than at some other point (as an example the outside top of a buried tank and the bottom of the tank or the inside bottom and top of a steel water storage tank). Where the oxygen is less plentiful, the structure will corrode. This action is like the plates of a storage battery and the structure itself closes the electrical circuit allowing current to flow continually. The remedy is to prevent the environment from contacting the pipe, or applying cathodic protection, or applying a coating supplemented by cathodic protection.

Differences in acidity or in scale formations also produce corrosion of a structure. The remedy is to prevent the environment from reaching the structure or applying cathodic protection.

These are the most serious forms of corrosion and are only described briefly here. An entire book may be written on each form of corrosion if one desires a full knowledge of each. With the limited space here, only brief mention can be made of the most serious cause of corrosion. Many other causes such as dissimilar metal corrosion, cavitation, metal fatigue, etc., can be mentioned, but almost everyone is aware of such corrosion, the same as experience has shown most operators that cinders are very destructive.

Figure 5 — This hole in a 4-in. main gave no visible surface indications. It also was quickly picked up by the leak detector.

Cathodic protection has been frequently mentioned but its use involves "interference" with other structures. It should be used in a plant or city street only when the damage to other stuctures has been carefully considered.

In all industrial plants there are many conditions of corrosion which could be eliminated if the operators were willing to have proper studies of the conditions made. Most operators wait until the ten or twenty year cycle brings to light serious corrosion failures and they then frantically call for a corrosion engineer to rush in, wave a magic wand over the plant, and hope he can stop the corrosion. In most cases it would be better for the operator to merely cross his fingers and keep his eyes closed for the next few years. While these comments may seem facetious, they are meant merely to tell the operator that if he has buried pipe lines and tanks, elevated tanks for water or any liquid storage, condenser systems for cooling, deep well systems, high velocity water suction systems, or water lines not treated on the inside to prevent corrosion and fungus growths, not to wait for the time when corrosion catches up with him but to start considering the corrosion now.

There are many corrosion engineers with only a few years experience who can handle simple forms of corrosion. Also, many operators try to worry out the problem themselves. Corrosion of plant structures and pipe lines is a very complicated process and no one can predict what will occur under installation unless the proper tests are made on the proposed site. It would be well for operators to stick to their operating and have someone who knows all the possible pitfalls in corrosion mitigation do the worrying for them. An experienced corrosion engineer can make a few simple tests backed by his knowledge of corrosion and quickly give an economic answer.

If the corrosion problem were simple and straightforward, you may be assured there would be some book written which would answer all your problems. There is not any such book to answer all your problems although there are many fine books on special phases of the problem. But do not expect to have a "cure-all" handed to you. You cannot treat cancer at home by reading a book. Most of us know this and generally get a doctor. So do not expect to answer the corrosion problem by a few years casual study.

DISCUSSION

PRESENTED BY

W. W. KOMPART, Combustion and Hydraulic Engineer, Weirton Steel Co., Weirton, W. Va.

L. S. STEINER, Superintendent of Maintenance, Steel and Tube Div., Timken Roller Bearing Co., Canton, Ohio

G. H. DANN, Engineer and General Superintendent, Philadelphia Suburban Water Co., Bryn Mawr, Pa.

V. C. ORANGE, Superintendent, Maintenance and Service Department, Atlas Steels, Ltd., Welland, Canada

W. W. Kompart: In our community we still believe and practice flushing of mains to remove sediment and build-up, as well as to prevent bacteria growth in dead end sections. In our experience we have known of towns with a population of from 50,000 to 70,000 that have no record of the location of the water lines. With an instrument such as described in Mr. Dann's paper it would not be too great a task to bring water line prints up to date.

With the present comparatively high cost of filtration plant operation and possible higher costs in the future, water line leaks should receive the proper attention. In some cases the stopping of these leaks may put off to a future date present high cost expansion of filter plants and pipe lines.

We have known of some systems that have operated with an unaccounted for water loss of 50 per cent, whereas good practice should not be over 10 per cent. Installation of orifice plates in main line branches to be used in conjunction with portable meters can be very helpful in determining leaks and pressure drops.

In our community a notable decrease in leaks due to electrolysis has been experienced with the removal of electric trolley systems. Corrosion and build-ups have not been a serious problem. When build-ups do occur there are several companies available that do an excellent job of pipe cleaning.

L. S. Steiner: In the method of leak survey that Mr. Dann described, he made one statement that I wish he would elaborate on. In describing this method he stated that he started at the source of supply and added a segment of piping from valve to valve. I do not quite understand what he meant by that, and I wish Mr. Dann would explain more fully.

G. H. Dann: There is a system of leak survey where you take a certain town and start at the source of supply, whatever it might be, a reservoir or a pumping station, and you set up on pipe line from this source of supply a U-tube or some measuring device. The control valve away from the supply point is closed and your measuring device measures no flow. Then going along the supply line to the next shut-off valve, this valve is closed and the first valve is opened, thereby a segment of pipe line is then being supplied from the source of supply through the measuring device. If there is no increase, it shows no leakage in this area. Then by this same method other sections of pipe are added to the original piping measured from the source of supply.

During this process there is a sudden increase in your measuring device located near the source of supply. Let's say it is 50,000 gallons going into a certain area. This area is noted. This continues throughout the night work period. During the following day time, inspectors go around in these suspected areas which are defined from a certain valve to a certain valve, and listen at available points such as valves, curb stops and hydrants for suspected leaks; sometimes they are leaks, sometimes the indication was caused by use, sometimes it is water that is being used but not metered.

L. S. Steiner: In using the pipe locator that you described, is it necessary to make an electrical connection between the transmitter and the pipe you are probing for and if so, how far out? What is the maximum distance on the system that you can reach and probe for this point? You mentioned the minimum, I do not believe you mentioned the maximum.

G. H. Dann: The locator is in two suitcases, one a sending set and the other a receiving set, and are not connected by wires. It is not necessary, as in some old pipe locators to string wires to complete the circuit. It is not necessary to connect to the pipe to be located unless there are a number of pipes close by that would be touching each other. The minimum distance that the sender and receiver should be located at any time apart is 30 ft. At one setting, you might go a maximum of 1500 ft. The distance is determined by the type of structure that you are following, an electrical cable might be followed for one-half a mile, while a pipe line can be located as fast as two men can walk, keeping their minimum distance apart. It is only necessary for these two men as they walk, to keep their receiver on the beam.

Then if you want to get the exact location you can by your receiver note the point exactly below where you have your maximum reading, with your receiver at right angles to the ground. Then for checking purposes, turn your receiver parallel to the ground and you will have a null sound exactly over the pipe.

L. S. Steiner: What would happen if this pipe was adjacent to other pipes or steel structures?

G. H. Dann: If this pipe is adjacent to other structures, but not touching other structures, you have a wire with which you induct current into the pipe and then with the receiver you locate the same pipe line.

L. S. Steiner: Using this electric detector, you state that you filter out other noises that you do not want. Are they always in a very narrow wave band so you can readily pick up those that you do want?

G. H. Dann: I would say so. Probably 85 per cent of all other noises would be filtered out.

L. S. Steiner: In other words, with a little experience in using this, the skilled man could easily pick out the noises that he wants?

G. H. Dann: Yes. One of the things I know of in the same wave band is steam escaping from a locomotive which sounds exactly like a leak.

V. C. Orange: We had an occasion, about a year ago in the plant, when we had a leak on a main line. It was a serious leak and it occurred about 5:00 o'clock on a Saturday evening, which was fortunate because departments fed by this line were down for the week-end. It had to be repaired before Sunday night or we would have been out of luck on one of our main production departments.

We went at it in the old way of trenching across the line to locate the break. We made a series of trenches as we knew the general direction of the pipe. We dug a distance back from where the water was surfacing but found that the water was coming from back along the pipe and had not surfaced at the point of break due to heavy stone fill over the pipe. We continued to meet water as we trenched across the pipe at intervals, and finally, since it was so important, we had to put more laborers on this work as there was no time to be lost.

One of the men happened to remember on Sunday afternoon, that the City of Welland had a leak detector; so we contacted the head of the water department and he was kind enough to send out the detector with a man to operate it. He located the leak about 20 feet further beyond our last trench, or a distance of approximately 70 ft from where water surfaced. In time, by trenching

we would have found it, but we probably would not have been ready for operations Sunday night. The reason it had not come to the surface was that on top of the stone fill we had a hard dirt fill over that area for a distance of probably 150 ft, so that the water travelled along following the stone until it reached the end of the stone area before surfacing.

With the detector he spotted the location of the leak exactly. After this demonstration, we purchased one of these detectors and had our pipefitters trained to operate it.

By our meters on a 3 in. city water line in the plant, we know we had a leak. This was a long line but there was no surface indications anywhere to indicate its location. To locate this leak by trenching would be a long drawn out job, however, with the use of the detector it was located at the very edge of a heavy concrete truck driveway and at a distance of about 6 ft from a building foundation.

A mark was made on the foundation indicating the point determined by the indicator. Upon digging down at this point, the leak was found and easily repaired with a sleeve as it was a clean break. The water from this leak had gone into the crushed stone fill under the paved road and as this was the point of least resistance, it surfaced at no point but continued to flow through the stone until it finally seeped into the ground.

Had we trenched either alongside the building foundation or at the opposite side of the road, it is doubtful if we would have found the leak and the meter would have continued to tell the story of lost water for some time. This job alone paid for itself twice over in the saving made by locating the leak by detector vs. trenching.

I might mention an instance where a detector would have saved many of us a "brain storm" had we had a detector at that time. This was a 4 in. water line which broke just inside the wall of an 18 in. bar mill furnace pit. The pipefitters did not know the location of the shutoff valve on this line and this particular plant, which is an old one, had no lay-out or prints showing the old water lines and this break was on one of these. The boss pipefitter, an old man who had put in these lines years ago, tried all the valves he could think of without any effect. The water was still rising in the furnace checker chambers and the furnaces would have soon been killed. Finally he had a faint recollection that years before there had been a valve somewhere around the charging tracks of the blooming mill soaking pits. They located the water line there and found the valve buried 4 ft under a switch with no valve box or any indication whatever of a valve at that point.

Any of you men who were in plants years ago will remember that very often the pipefitter boss was an old man who knew all of the pipe lines, and as in the instance cited above, the plant had to depend on him since they had no record of pipe layout. A leak detector changes this condition materially. I do not know whether it would work as far as gas is concerned or not, but I do know it works on water.

There is one thing I would like to ask Mr. Dann, in relation to the determining of the size of the pipe, will that hold good also, for locating valves?

G. H. Dann: Speaking of locating the size of the pipe by this pipe locator, the place where you use it practically is this: where there is a main in the street, maybe two or three of them, and one is a six inch, one is a ten inch, one is a sixteen inch. You want to plot them, find where they are, and so often, during the paving program, you will want to know where the sixteen inch goes and where the four inch goes, and where the six inch goes, so you will actually use this method to find the size of the pipe.

Now, as far as locating curb boxes or valve boxes with this machine is concerned, yes, it can be done. In fact, this machine with certain refinements, is used in the western parts of the United States to prospect for gold. The only thing is that this refined type of machine that might detect gold can only be rented, not purchased; but actually, it is the same principle. You can go along and find a buried metal object in the ground with this machine if the object is within a reasonable depth.

V. C. Orange: What I had in mind is could you define or possibly locate the valve? In this case that I spoke about, if the detector could have been brought over the valve, and forgetting the switch over it, would it have given an indication of the valve having been at that point?

G. H. Dann: Yes. You first use the locator as two separate suitcases, plotting the line of the pipe. After your line has been plotted, you hook two suitcases, that is, the sender and the receiver, together with shafts in between them just like the old buggy days, and while you are walking along the line of the pipe as previously plotted, when you pass over a metal object, you get a definite indication. By actual experience, corporation cocks on the top of mains, have been located, buried 4 ft in the ground. You get a high pitched indication as you pass over the object.

Member: I want to say that we have used the so-called electroplated bitumenastic on 12 in. pipe lines. We have had it in service now about fifteen months and expect to open it up pretty soon. We have a "T" in the line which we take out to find out just what the inside condition of that line is. We do not doubt that it will do the job that the people said it would do, but we just want to see what it does do under our particular salt water conditions and so forth.

We have had a lot of trouble with leaks in underground gas mains. Would it be possible to detect those?

In some cases we have had areas around the pumping station where the whole ground was more or less saturated with gas, and after smelling for it, or looking for it with an explosion meter, it did not give us satisfactory results because the whole area was saturated. I was wondering if you have had any experience in locating any definite leaks?

G. H. Dann: I might say that if there is pressure on the gas line or if there is another line where there is a vacuum with a small hole in it, whether the pressure or vacuum is high or low, vibrations are set up and the locator will pick up these vibrations. We have found leaks on heating systems of the vacuum type which are the reverse of the usual leakage due to pressure. We have built up good will locally many times, by locating leaks on heating companies' lines and could locate leaks on gas lines if the lines were under pressure.

MAGNETIC TORQUE A-C CRANE CONTROL

. . . . the use of an eddy-current brake to preload a wound rotor motor gives a-c cranes the exacting control characteristics usually only associated with d-c operation . . . .

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and
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▲ ELECTRO-MAGNETIC torque motor control was first introduced in the year 1942 on large excavators in the form of a clutch. Prior to that time power transmission in these machines was generally accomplished through friction clutches, which was one of the greatest sources of maintenance. Replacements of linings, scoring of drums, grabbing of clutches or excessive slippage, all of this meant constant adjustments and maintenance. Magnetorque control of large electric excavators has had phenomenal success, it has been foolproof, simple in construction, and free of maintenance.

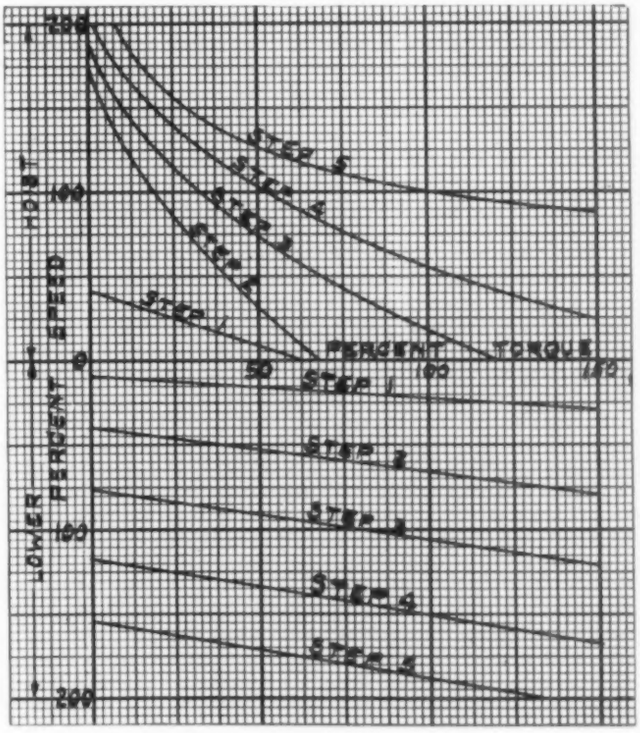
Knowing the difficulties with mechanical load brakes on cranes and the maintenance problems connected with them, it has been a challenge to engineers to develop a control to eliminate the mechanical load brake. During the early history of overhead traveling cranes, the mechanical load brake was used for both direct current operated as well as alternating current operated cranes. In the period of 1910 to 1914 dynamic lowering control was introduced on direct current operated cranes and it eliminated the troublesome mechanical load brake. Since its introduction, it is now the adopted standard method of control on all d-c cranes. The problem of eliminating the mechanical load brake on a-c cranes was a big one, because of the pattern set forth by d-c dynamic lowering control. Such good speed control was hard to duplicate with a-c.

Because of the good speed control characteristic, direct current cranes have been most frequently used in industry. This is especially true where close speed regulation is necessary for a wide variation of loads, ranging from no-load to full-load. In a great number of instances this necessitates the addition of direct current power supply and in some instances separate motor generator sets were required to supply direct current for the crane or cranes.

Therefore, in the past, the primary reason for preference of direct current cranes has been the speed control particularly for the hoist motion. On d-c operated cranes, the mechanical load brake is replaced with an electrical braking system. With no-load, or non-overhauling loads, the motor draws current from the line, motor action provides power lowering of the hook. When the load suspended from the hook is of sufficient capacity to overhaul the hoisting mechanism, the current in the armature reverses and motor action is reverted to generator action, or dynamic lowering. Speed control and braking capacity are determined by increasing or decreasing the motor field and armature strength through external resistance. This type of control gives very flat speed-load characteristics for varying loads from no-load to full-load. Figure 1 illustrates the speed-torque characteristics for this type of control.

With the increase in alternating current power supply, in recent years there has been a great deal of research and development to improve alternating current crane control. Engineers sought to eliminate the mechanical load brake and to acquire the same speed con-

Figure 1 — Speed-torque characteristics of d-c dynamic lowering control.



Presented before AISE Annual Convention, Cleveland, Ohio, September 30, 1948

trol characteristics as for d-c dynamic lowering control.

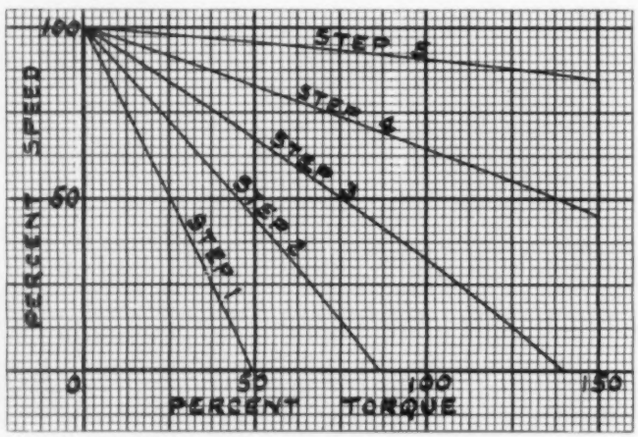
The wound rotor induction motor is the type generally used for a-c crane hoist drives. Since a general understanding of its performance characteristics will aid in the proper selection and application of the control scheme, Figure 2 is shown. Notice how it illustrates the lack of speed control under no load and light load. These speed torque curves are obtained in the conventional manner for secondary resistance control of a wound rotor induction motor.

Several control schemes using the wound rotor induction motor have been developed. These include mechanical load brake and electrical controls that eliminate the mechanical load brake, such as regenerative lowering, counter-torque, direct current braking, single phase lowering, adjustable unbalanced voltage, reactor control, and more recently, electro-magnetic torque. Of these, only electro-magnetic torque approaches the speed-load characteristics of d-c dynamic lowering as brought out by the following comparative control descriptions. All curves shown herewith have been replotted to the same scale and were taken from published data.

The mechanical load brake is a device designed to apply a braking torque in the lowering direction, and is not effective in the hoisting direction. The load on the hook locks the load brake, the degree of locking being determined by the load, the greater the load the greater the locking effect on the brake. The load brake is unlocked by running the motor in the lowering direction. As the locking effect increases with increased load on the hook, the power required by the motor also will increase. Since the load brake is a friction device (usually running in oil), it has an erratic variation in speed load characteristics caused by wear of friction surfaces and gear case temperatures. Figure 3 illustrates typical speed torque characteristics for this type of control.

Regenerative braking is limited to installations where slow lowering speeds or speed control are not essential. The hoisting motion provides conventional speed load characteristics. With this type of control, no mechanical load brake is used. The load overhauls the motor and the lowering speed cannot be reduced below the synchronous speed of the motor. Secondary resistance steps are only used to limit the inrush current of the motor. The slowest speed obtainable even with the rotor short-circuited, is above synchronous speed in

Figure 2 — Speed-torque characteristics of conventional a-c hoist control.



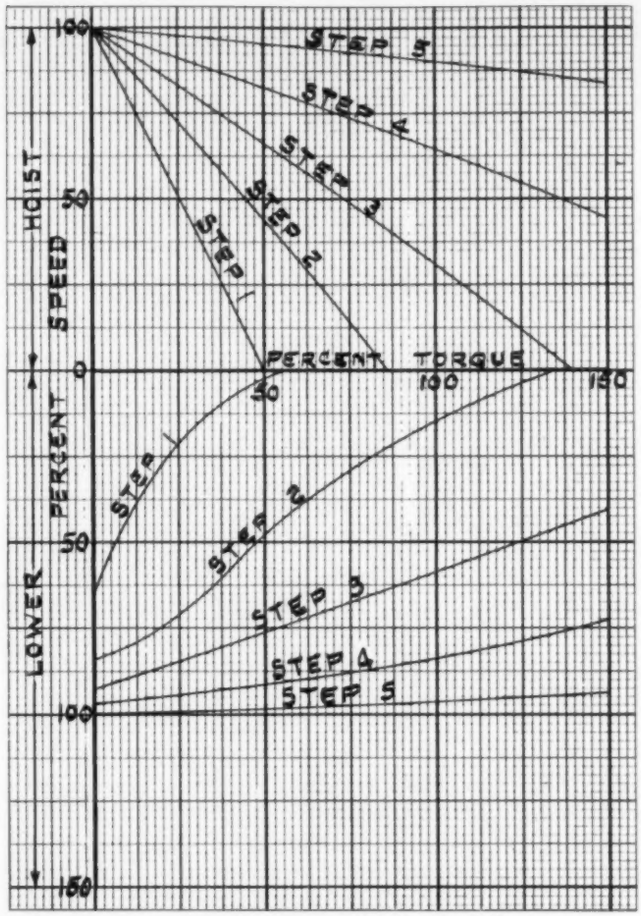


Figure 3 — The curve shows typical speed-torque characteristics for mechanical load brake control.

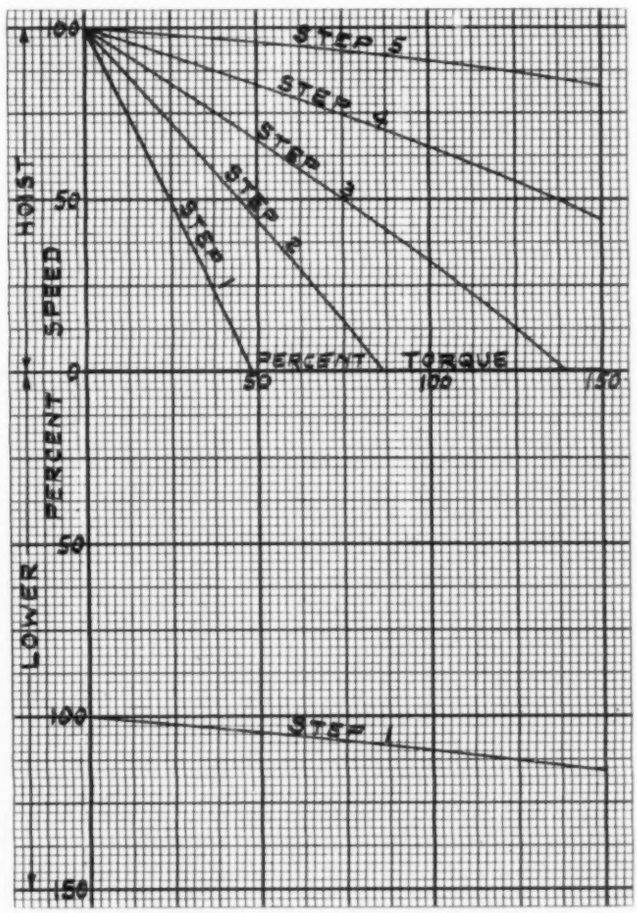
amounts determined by the motor slip. Operating on any of intermediate control speeds will result in excessive motor speeds. Figure 4 illustrates the speed torque characteristics for this type of control.

Counter-torque control is limited to applications where a definite load is suspended from the hook at all times, such as bucket or magnet cranes. The hoisting direction provides conventional speed control. In the lowering direction this type of control provides speed control at sub-synchronous speeds for overhauling loads only. When lowering, a hoisting torque is exerted by the motor, the load overhauling the motor, hence, the name counter-torque. The motor speed is varied by varying the amount of external secondary resistance, increasing the ohmic value of the external resistance reduces the motor torque and increases the lowering speed. Since the speed-load curves for this control are very steep the speed regulation is poor. The possibility also exists that on a given step the load may hoist if the motor torque is greater than the torque exerted by the overhauling load. This makes this type of control impractical for production or hook cranes. This control usually includes at least one step of regenerative lowering, to lower light or non-overhauling loads. Counter-torque lowering control is generally used for rough handling cranes, providing an electrical slow-down before stopping, thereby relieving the motor brake. Figure 5 illustrates the speed-torque characteristics for this type of control.

Direct current braking control is a method by which the primary of the wound rotor induction motor is excited with direct current. The direct current passing through the motor primary winding sets up a stationary field producing a retarding torque in the motor which reduces the speed when lowering an overhauling load. The resulting speed load curves converge at zero speed and thus prevents inadvertent hoisting of light loads. This results in steep speed-load characteristics. This method also includes at least one regenerative lowering control step to lower light or non-overhauling loads. Direct current braking control has poor speed control in the lowering side especially in the low torque area. Direct current excitation current greatly exceeds full load motor current. In hoisting conventional speed control is obtained. Figure 6 illustrates typical speed-torque characteristics for this type of control.

Single-phase lowering control is frequently referred to as a-c dynamic lowering. This is a method using single phase excitation on the motor. This control has only one step of single phase braking and its characteristics can be varied by changing the value of the external secondary resistance. The use of the single phase braking control results in excessive unbalanced motor currents. For an example the motor primary current values in each phase of a typical motor when connected for single-phase braking, and, when lowering full load, are recognized as follows (quoting from a recent publication):

Figure 4 — Characteristics of regenerative braking control.



Phase	Per cent of rated primary phase current	
	Primary connected delta	Primary connected wye
1	170	177
2	155	137
3	107	118

With this type of control, the motor cannot exert a revolving torque, therefore, it is impossible to lower non-overhauling loads on this control step. The resulting speed load curve passes through zero speed at approximately no-load and has a steep characteristic. This control also includes at least one regenerative lowering step, to lower non-overhauling loads. Hoisting is accomplished in the conventional manner. Figure 7 illustrates the speed-torque characteristics for this type of control.

Adjustable unbalanced voltage control utilizes an auto-transformer in two of the three motor primary phases. The transformer having a number of taps, changes the degree of unbalance on the various control steps. The speed-torque characteristics obtained in lowering give fair speed regulation on loads of 50 per cent and less, but lacks slow speed control on heavier loads. Also, this type of control employs at least one step of regenerative lowering. In hoisting conventional speed control is obtained. This control, same as single-phase lowering control, results in excessive motor currents. For example, the motor primary current values in each phase for this adjustable unbalance voltage control when lowering full load have been published as follows (quoting from a recent publication):

Phase	Per cent of rated primary phase current	
	Primary connected delta	Primary connected wye
1	218	236
2	198	146
3	98	110

Figure 8 illustrates the speed torque characteristics for this type of control.

Reactor control is a variable unbalanced voltage control, where the degree of unbalance varies as a function of the motor speed. By the use of a saturable reactor in one motor phase and a phase shifting device, fairly good coverage when lowering is obtained although the speed-torque curves are fairly steep. The motor currents in any phase do not exceed 125 per cent of full load motor current, and, therefore, this control does not have the disadvantage of excessive motor currents as other unbalanced voltage control schemes. This control also employs at least one step of regenerative lowering. Figure 9 illustrates the speed-torque characteristics for this type of control.

All of the a-c controls so far considered have similar hoisting characteristics, obtained through external secondary resistance, as shown on the respective speed-torque characteristic curves. These controls afford good selection of hoisting speeds for loads requiring motor torques of 40 per cent and greater, but the speed regulation for lighter loads is poor. These controls which operate without mechanical load brake do not allow

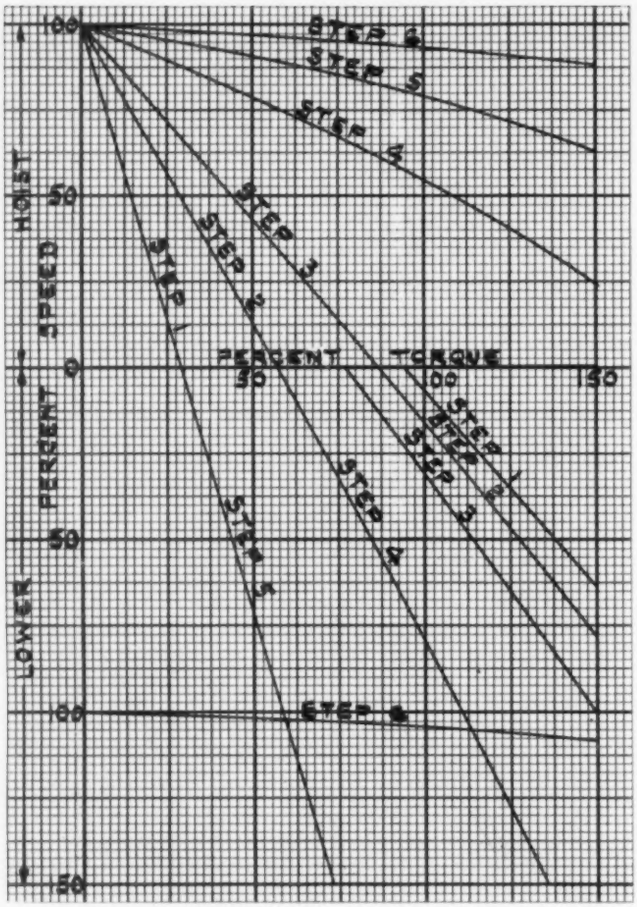


Figure 5 — Speed-torque characteristics of counter-torque lowering control.

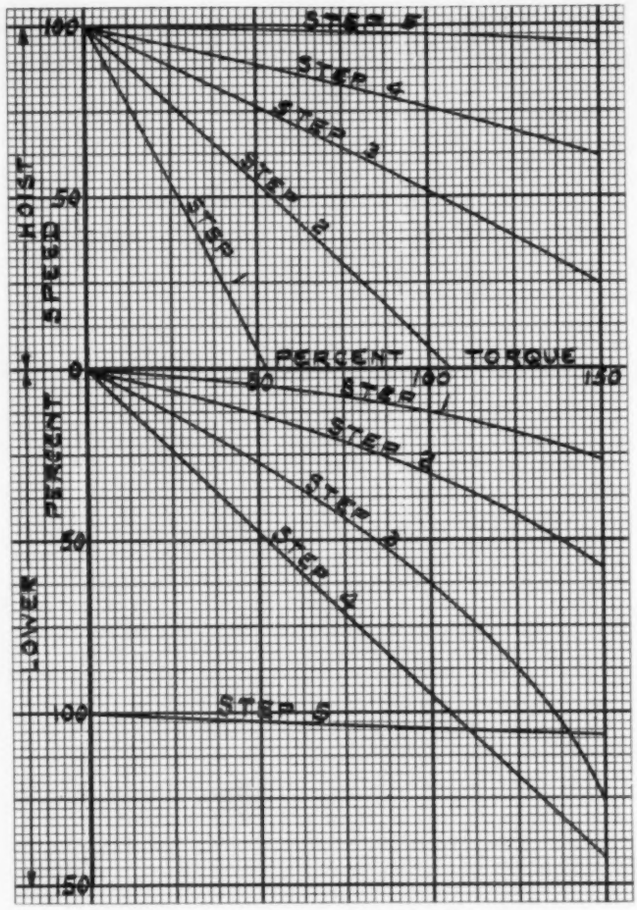


Figure 6 — When d-c excitation braking is used for a-c hoist control, speed-torque characteristics are as shown in the sketch.

positive hoisting of heavy loads on the low torque steps, nor do they prevent heavy loads from lowering on these control steps.

ELECTRO MAGNETIC

This control uses an electro-magnet to exert a torque on the motor to preload the motor and thus utilizes the better part of a slip ring motor's characteristic. The wound rotor induction motor, due to its inherent characteristics, is the most desirable type for crane service. Since slip ring motors have poor speed regulation under no-load or light-load conditions, the motor tends to run at synchronous speed. Therefore, the new control incorporates an electrical brake to preload the motor and provides speed control of a normally loaded motor without the use of a mechanical load brake.

This brake is a device for transmitting torque through electro-magnetic fields, there being no mechanical connection between the stationary and rotating members. Figure 10 illustrates this brake. The stationary field member comprises a doughnut shaped coil, excited by low voltage direct current, encased in a circular magnet spider. This spider is arranged to provide a large number of alternate north and south magnetic poles. The rotating member, or rotor, is very light in weight for the horsepower transmitted and consists of a thin special iron drum supported on a large number of radiating fins that also combine to make the hub support. The rotor drum is split in several sections to permit circumferential expansion and maintain a uniform air gap when the drum is heated as a result of carrying heavy eddy currents.

A great variation in the character of the torque curve can be designed into the brake. Torque characteristics are controlled by design of magnet poles, rotor drum dimensions, and quality of material.

The stationary field member is rigidly mounted on the outside of the hoist gear case and centered about the outboard motor pinion shaft bearing capsule. The rotor is mounted on motor pinion shaft extension and rotates at motor speed. The motor is directly connected to the hoisting drum at all times. A typical mounting arrangement is shown in Figure 11. Since the field member is stationary and the rotor has no electrical connection, there are no moving electrical parts requiring maintenance. The braking torque is accomplished through magnetic lines of force between the stationary field member and rotor. Therefore, only magnetic lines are broken—the result—no wearing parts, no replacement of friction surfaces. Direct current excitation to the stationary field is obtained through a step-down transformer and a selenium rectifier. Control results are achieved with the eddy current brake exerting a torque opposing the driving torque of the motor. By properly matching the motor torque through secondary resistance, and the braking torque through resistance which controls the eddy current brake excitation, the desired characteristics are obtained.

This control provides superior speed regulation over any other a-c crane control and actually excels the control available with d-c dynamic lowering control. An analysis of the speed torque curves, Figure 12, will emphasize its superiority. In hoisting, all loads can be controlled at slow, medium, and high speeds. An outstanding feature of the control is the fact that it is impossible for the load to lower with the controller on any hoist position. Even on the first hoist control step, the load will always raise through the entire load range from no-load to 125 per cent of rated crane capacity. As there is only a 15 per cent change in speed from no-load to full-load on the first step of control, the hoist unit will gradually take the slack out of the sling and then smoothly raise the load. This is a very desirable feature and eliminates the necessity for inching or jogging. When heavy loads are only partially raised and then stopped, the load will not lower when hoisting motion is resumed, which is the case on all other schemes, including d-c dynamic lowering.

In lowering, all loads can be lowered at slow, medium, and high speeds; this is true for overhauling as well as non-overhauling loads. Capacity loads can be lowered at 10 per cent of full load hoisting speed, which means accurate spotting of all loads, without the necessity of inching or jogging. The characteristic curves show that this control insures positive hook action, no inadvertent lowering when hoisting is expected, and flat speed load characteristics on all lowering speed steps.

Off-position braking is a safety feature with the control. With the controller in the off-position, the eddy current brake is excited at a reduced voltage. In case of electric motor brake failure, the load will overhaul the hoisting unit, but the brake will exert a braking torque to slowly lower the overhauling load to the floor, thus preventing a free falling load. This safety feature is not available on any other a-c control and is only obtainable with d-c dynamic lowering or load brake control.

When desired, an additional safety feature can be incorporated with the control and is known as all position braking. This feature consists of an auxiliary permanent magnet alternator and rectifier, with an automatic switching means for excitation of the electro-magnetic torque brake. In case of simultaneous power and electric motor brake failure, the suspended load will overhaul the hoisting unit. In this case the alternator will automatically generate current and excite the brake, thereby retarding the overhauling load speed to approximately 20 per cent of full load speed. This safety feature is accomplished regardless of position of controller handle, off-position, or on any running position. The alternator is open circuited under normal operation and is only inserted when the main line disconnect switch is open, or in case of power failure. The all position braking feature is similar to the off-position dynamic braking as obtained with d-c dynamic lowering control.

The motor circuit, electro-magnetic torque circuit,

Figure 7 — Speed-torque characteristics of single phase lowering control.

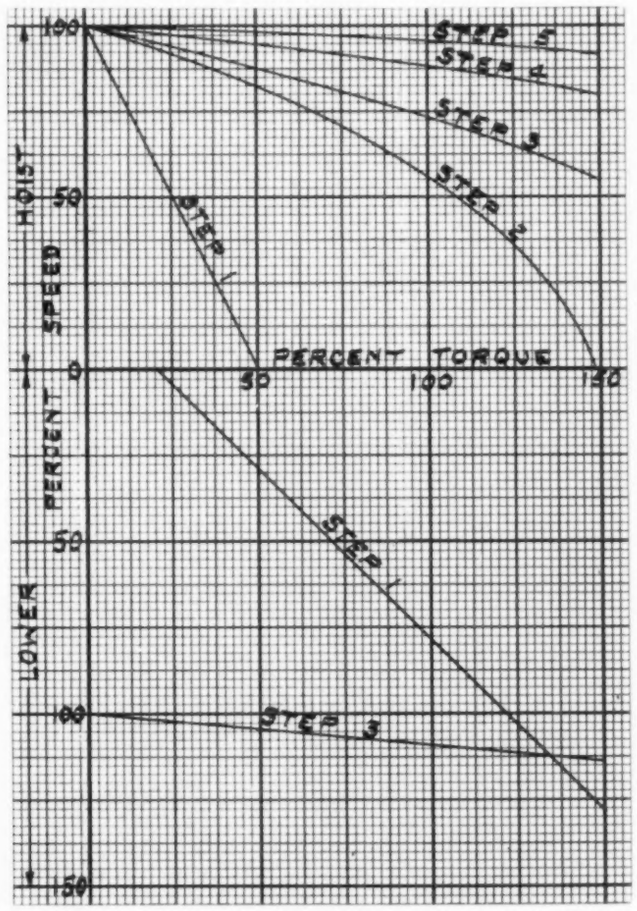
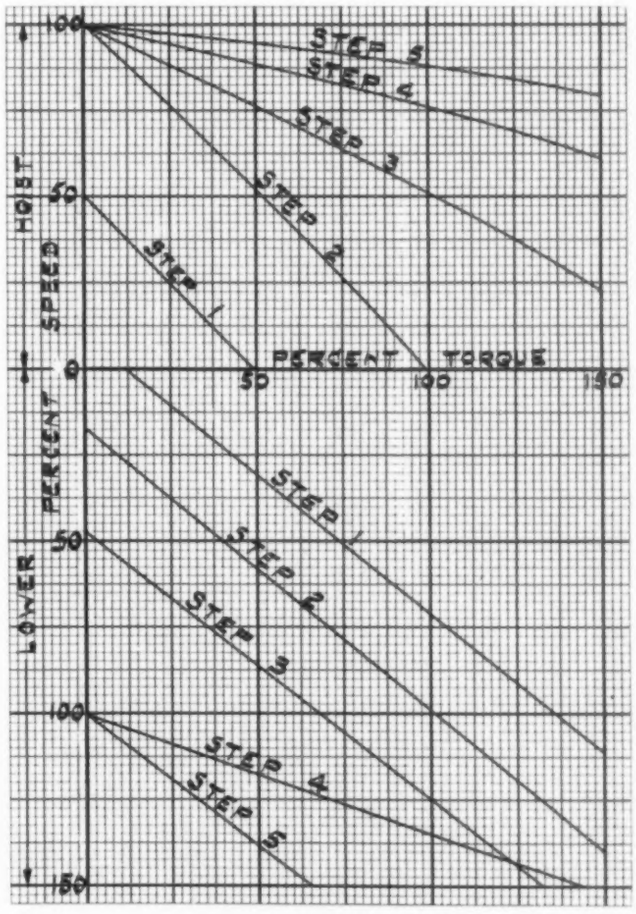


Figure 8 — Speed-torque characteristics of adjustable unbalanced voltage control.



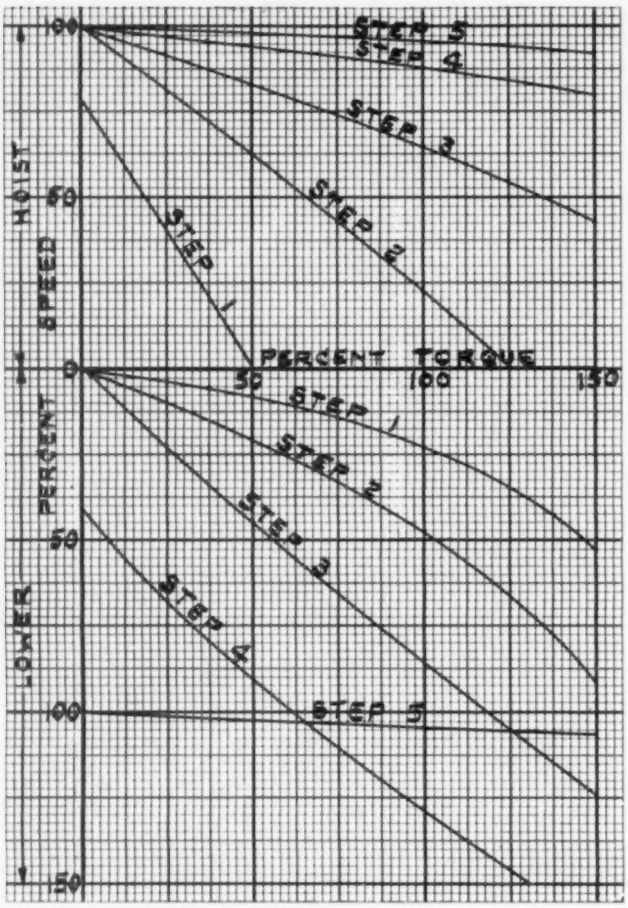


Figure 9 — Speed-torque characteristics of reactor variable unbalanced voltage control.

and control circuit are shown in Figure 13. A series relay SR is connected in series with the magnetic torque field circuit. This relay insures excitation on the unit before the motor directional contactors H and L can close, except hoisting steps No. 3, 4, and 5, and regenerative lowering step No. 5 because on these steps the magnetic torque brake is not excited. This insures positive safe control in case of an open circuit in the brake. Failure of current in the brake circuit will result in opening of SR current relay, automatically opening the directional contactor coil circuits, thereby interrupting the motor and electric motor brake circuits.

The magnetic torque unit is energized by a low voltage d-c obtained through a step-down transformer and a selenium rectifier, the transformer primary being connected directly across the load side of the main knife switch. The sequence of operation of a full magnetic torque control is as follows:

Step No. 1 lower—The brake circuit is first energized, which energizes the current relay SR, closing the power supply to the control circuit. Contactors 75 and 100 close energizing the brake circuit, directional contactor L closes energizing the motor primary and releasing the electric motor brake. This is maximum magnetic torque excitation with the motor secondary open circuited; there being no motor torque developed, with the result of zero speed for non-overhauling loads.

Step No. 2 lower—On this step directional contactor L and magnetic torque contactors 75 and 100 remain closed. Motor secondary accelerating contactor 1A closes, closing the motor secondary, with maximum external motor secondary resistance, and minimum motor torque.

Step No. 3 lower—Directional contactor L, magnetic torque contactors 75 and 100, and motor secondary accelerating contactor 1A remain closed. Motor secondary accelerating contactor 3A closes, short-circuiting a portion of the external motor secondary resistance, increasing the motor torque.

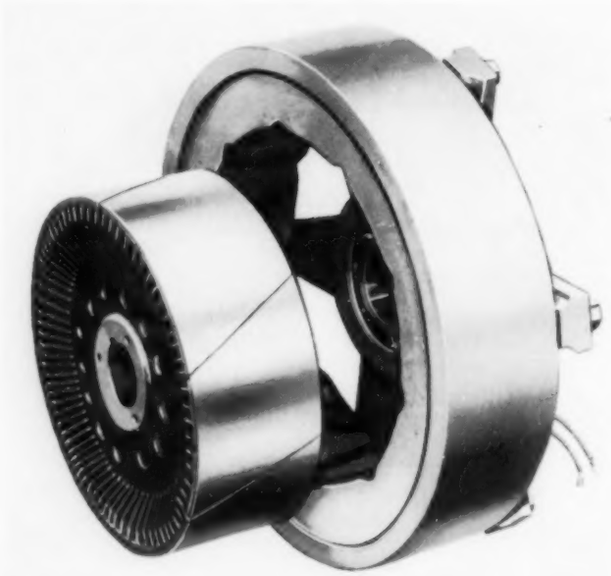
Step No. 4 lower—Directional contactor L, contactor 75, motor secondary accelerating contactors 1A and 3A remain closed. Magnetic torque contactor 100 opens, inserting resistance in the magnetic torque circuit, reducing the current and therefore the torque of the brake. Motor secondary accelerating contactor 4A closes, short-circuiting a portion of the external motor secondary resistance, increasing the motor torque.

Step No. 5 lower—This is a regenerative lowering step with the brake open circuited. Magnetic torque contactor 75 opens, opening the brake circuit. Contact L3X in the master controller closes, by-passing the current relay contacts SR, which open when brake circuit is open. Directional contactor L and motor secondary accelerating contactors 1A, 3A, and 4A remain closed. Motor secondary accelerating contactor 5A closes, short-circuiting all but the permanent slip resistance in the external motor secondary circuit.

Motor secondary accelerating contactors 4A and 5A are timed, the timing being controlled by an adjustable pneumatic timer operated by the preceding accelerating contactor. These timers only function if the master controller is rapidly thrown from the off to the full-on running position, and automatically accelerate the motor and keep the current inrush to a safe value. Although accelerating contactors 4A and 5A are timed, any control step can be held for any period as long as the master controller is held on the control step.

Step No. 1 hoist—This is the same as the lowering

Figure 10 — The magnetic torque brake transmits the torque as the name implies through electro-magnetic fields.



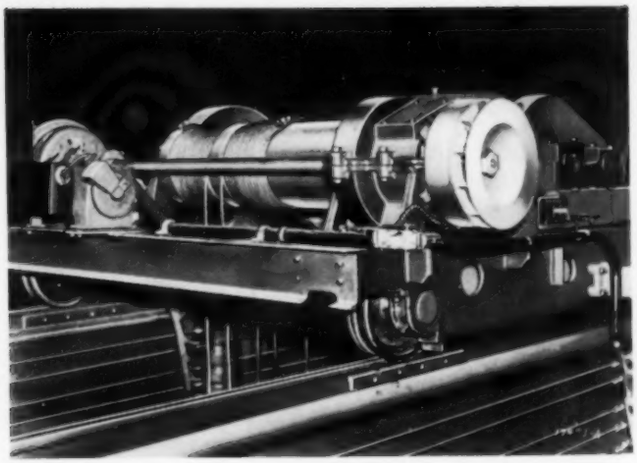


Figure 11 — On the mounting shown in this photograph, the motor is directly connected to the hoisting drum at all times.

circuit, the brake circuit is first energized, which energizes the current relay SR, closing the power supply to the control circuit. Contactors 75 and 100 close energizing the magnetic torque brake circuit, directional contactor H closes energizing the motor primary and releasing the electric motor brake. Motor secondary accelerating contactor 2A closes, closing the motor secondary and shorting out a portion of the external motor secondary resistance.

Step No. 2 hoist—Directional contactor H, contactor 75, and motor secondary accelerating contactor 2A remain closed. Magnetic torque contactor 100 opens, inserting resistance in the magnetic torque circuit, reducing the current, and, therefore, the torque of the brake. Motor secondary accelerating contactor 3A closes, short-circuiting a portion of the external motor secondary resistance, increasing the motor torque.

Step No. 3 hoist—Contactor 75 opens, opening the magnetic torque brake circuit. Contact L3X in master controller closes, by-passing current relay contacts SR, which open when brake circuit is open. Directional contactor H, and motor secondary accelerating contactor 2A remain closed. Motor secondary accelerating contactor 3A opens, inserting resistance in the motor secondary circuit and reducing the motor torque.

Step No. 4 hoist—The master controller contacts L3X, directional contactor H, and motor secondary accelerating contactor 2A remain closed. Motor secondary accelerating contactor 3A closes, short-circuiting a portion of the external motor secondary resistance, increasing the motor torque.

Step No. 5 hoist—The master controller contacts L3X, directional contactor H, and motor secondary accelerating contactors 2A and 3A remain closed. Motor secondary accelerating contactors 4A and 5A close, short-circuiting all but the permanent slip resistance in the motor secondary circuit.

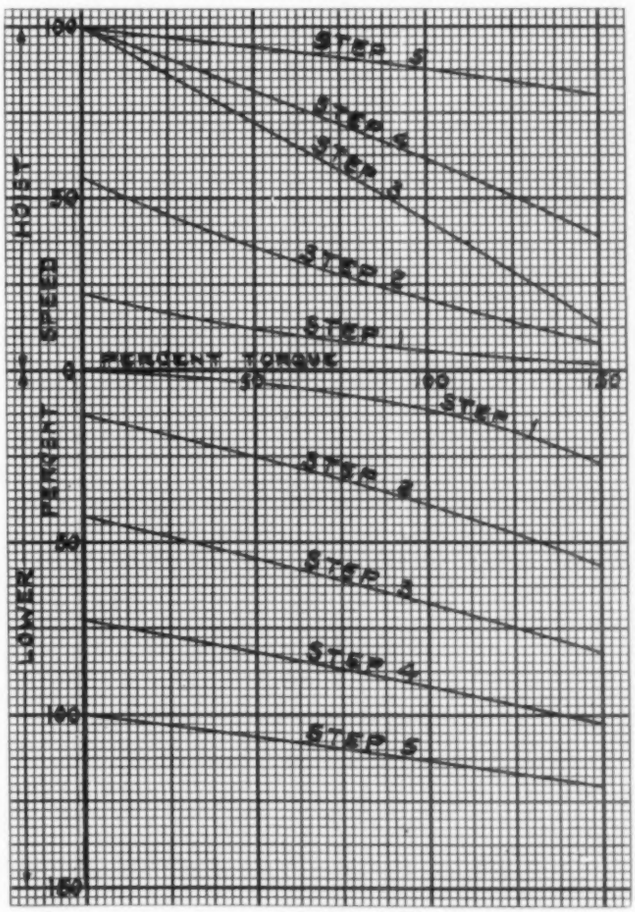
Motor secondary accelerating contactors 3A, 4A, and 5A are timed accelerating steps, the timing being controlled by an adjustable pneumatic timer operated by the preceding accelerating contactor. These timers only function if the master controller is rapidly thrown from the off to the full-on running position, automatically accelerate the motor and keep the current inrush to a safe value. Although accelerating contactors 3A, 4A, and 5A are timed, any control step can be held for any period as long as the master controller is held on the control step.

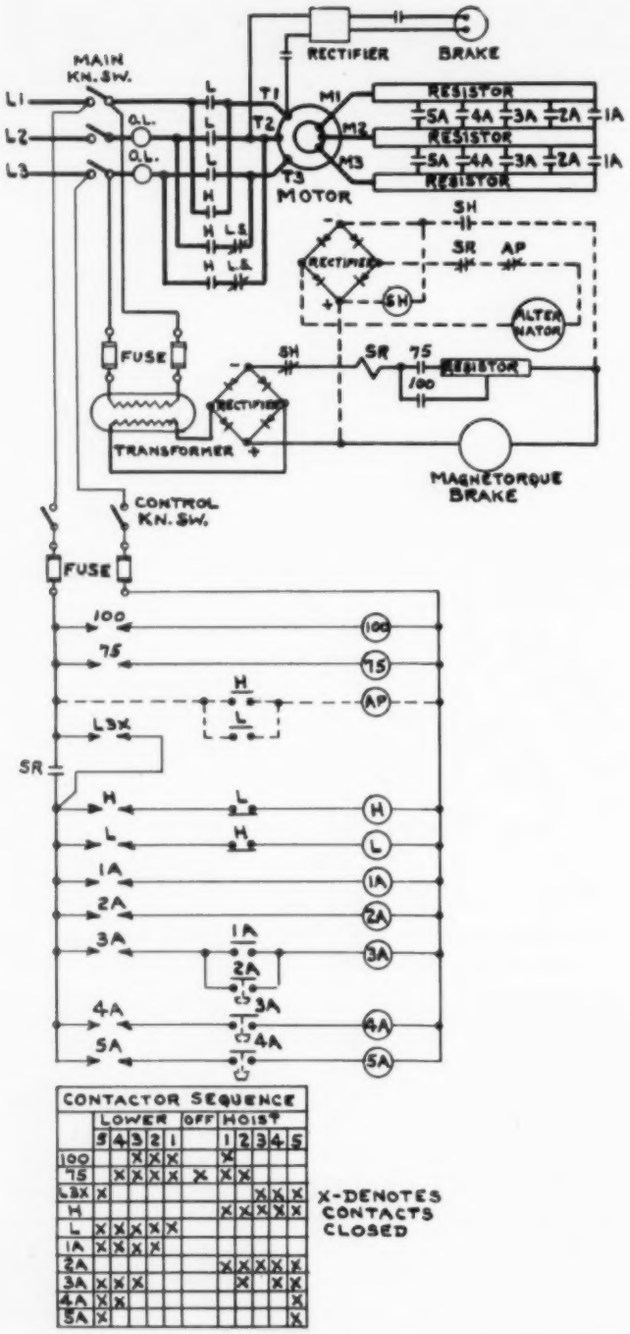
Off position—In the off position, contactor 75 is closed, energizing the magnetic torque brake with reduced current. This circuit serves as off-position braking to slowly lower an overhauling load to floor in case of electric motor brake failure.

All-position braking—The all-position braking circuit is shown in broken lines. In case of power and electric motor brake failure simultaneously, the load will overhaul the hoisting unit, the alternator will excite the rectifier through normally closed contacts on the current relay SR, and normally closed contacts on relay AP. The rectified current closes relay SH, closing the normally open relay contacts SH, energizing the magnetic torque brake circuit from the alternator, and opens the normally closed relay contacts SH, interrupting the rectifier circuit which normally energizes the brake.

To dispel any thought one might have concerning overheating with magnetic torque control, motor currents, based on per cent of full load motor current for the various control steps, are shown in Figure 14. These are actual values obtained from tests conducted on a standard 5-ton, 50 fpm hoist unit, using an NEMA frame 365 totally enclosed wound rotor induction motor rated 20 hp, 1165 rpm, 30 minutes 55 C temperature

Figure 12 — Speed-torque curves, when magnetic torque control is used, are illustrated in this figure.





CONTACTOR SEQUENCE

	LOWER					OFF	HOIST				
	5	4	3	2	1		1	2	3	4	5
100			X	X	X		X				
75		X	X	X	X	X	X	X			
L3X	X								X	X	X
H							X	X	X	X	X
L	X	X	X	X	X	X					
1A	X	X	X	X							
2A							X	X	X	X	X
3A	X	X	X				X		X	X	X
4A	X	X									X
5A	X										X

X-DENOTES CONTACTS CLOSED

Figure 13 (left) — Schematic diagram of magnetic torque control for crane hoist.

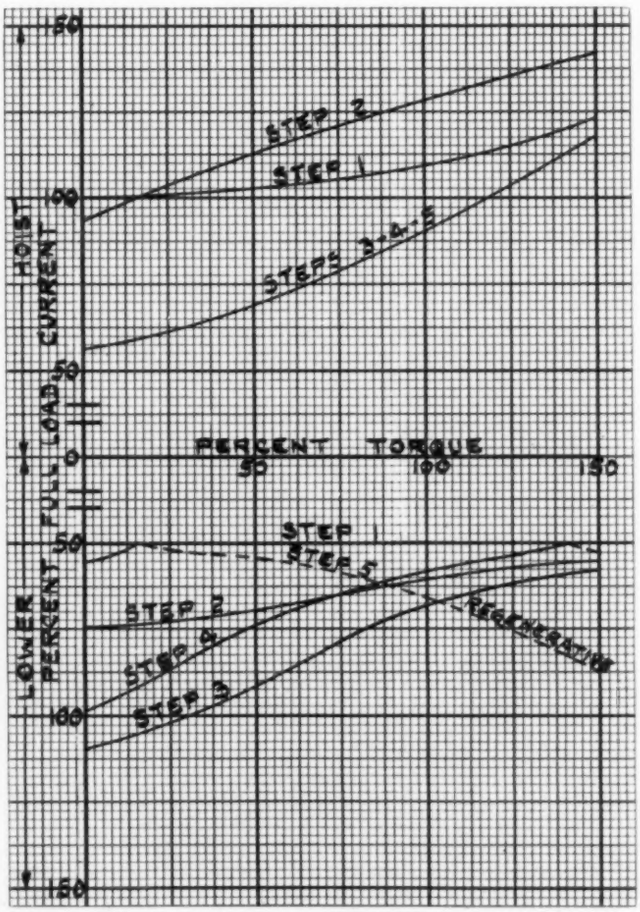
rise. This hoist unit is operating on a moderate service crane in a production assembly department. The motor current with magnetic torque control is within the limits of the motor currents in the d-c dynamic lowering control, which on the first lowering step is approximately 150 per cent of full load motor current. An automatic temperature recorder was installed on the crane to check the temperature rise of various parts of both the motor and torque brake. The following maximum temperature rises were recorded:

Motor		Magnetic torque brake	
Stator winding	45 C	Field ring winding	28 C
Stator iron	32 C	Air in	22 C
Air inside motor	32 C	Air out	38 C
Rotor winding (shut down)	41 C	Rotor (shut down)	22 C

Although we have confined our remarks mostly to full magnetic control, magnetic torque a-c crane control can be obtained in manual drum control as well. This allows it to be used on all types of crane installations giving the benefits of good speed control for all alternating current crane applications. The better speed regulation obtained with this control allows a higher full load hoisting speed to be specified and makes the a-c crane with its cheaper power a better production tool. The simplicity of the control circuit allows the average shop electrician to readily service these cranes.

In conclusion I would like to give you another example of this brake. We recently built an a-c high speed production yard crane where the operator's cab was attached to the trolley. This always presented a problem of providing a gradual braking means for the bridge. Formerly, solenoid or thrustor operated brakes were employed with no great success. The braking torque could not be gradually applied as with a mechanical or hydraulic operated brake. This crane installation was equipped with a magnetic torque bridge brake operated in conjunction with the control and provided a gradual acceleration as well as deceleration of the bridge.

Figure 14 — Motor current values on the various steps are given in this figure for magnetic torque control.



DISCUSSION

PRESENTED BY

H. H. ANGEL, Electrical Engineer, Construction Engineering Department, Bethlehem Steel Co., Bethlehem, Pa.

R. T. LUCAS, Assistant Electrical Superintendent, Weirton Steel Co., Weirton, W. Va.

JOHN D. LEITCH, Chief Engineer, Electric Controller and Mfg. Co., Cleveland, Ohio

F. W. WENDELBURG, Harnischfeger Corp., Milwaukee, Wis.

Harry Angel: How does the first cost of this control, which includes the magnetic torque current equipment, compare with the conventional controls which are available today? Also have installations been made on existing cranes where it is often quite difficult to even replace a magnetic brake?

Has the author run tests on any installations where the master switch is moved from the off position to full speed hoist very quickly, and in the same way to full speed lower? If so, have the resultant currents exceeded 200 per cent load?

Of course, we all realize that on many a steel mill crane, especially on the hoist, the operators accelerate very quickly. They do not operate point to point as we would like to have them do.

The next thing is, this new control apparently requires two extra trolley conductors and, of course, you have protection on open circuit. The SR relay takes care of that condition in which the hoist and lowering contactors are opened. Have you had any tests made which indicate any heavy increases in speed during an intentional opening up of this circuit during some test-lowering trials, and have these overspeed conditions, if they exist, caused any concern on the part of the operators?

R. T. Lucas: We have a considerable number of a-c cranes in our plant. The brakes have been one of our very bad problems. They stick. I think everybody who has had anything to do with them knows that they are difficult to maintain.

There are a couple of points in the paper that are not quite clear to me. One of them is on the last step of lowering. The magnetic torque brake is disconnected from the circuit. It seems to me that if you had a heavy load on the crane and were going down, and the crane operator put the controller on the fifth step, that it might possibly overhaul the motor and cause the motor to run at higher than its safe speed.

Another point is the first lowering step. The motor primary is energized with the rotor or the secondary open. It does not have any torque. According to the chart of motor current, that gives about 50 per cent primary current with no movement of the hoist.

I do not know about the rest of the companies, but I think some of our crane operators do not always do things the way the engineers would do them. If the hoist does not move on the first point, it is possible that the crane operator would leave that hoist controller on, and with no movement might forget it. Whether that would do damage to the motor or not, I do not know. It seems to me that the operation of the control at that point should not have any motor current in the primary.

The only thing that I can see that is accomplished is that the motor brake is opened up and the magnetic torque brake energized. The control scheme I think is very well designed. If these two points were cleared up, I think that I would like this control very much. We have a number of a-c cranes and have a lot of trouble with our hoisting and lowering operations.

John D. Leitch: The authors are to be complimented on a very excellent paper both in its content and its clarity. They have covered very well the various commonly used methods of d-c and a-c crane hoist control.

In particular they have stressed the use of an eddy current brake as an adjustable artificial load on a wound rotor induction motor. By means of this artificial load, they obtain combined speed-torque characteristics superior to those of the wound rotor motor alone.

Braking generators have been used, particularly in Europe, as artificial loads in conjunction with wound rotor motors for many years. They have been used on hoists to provide under-synchronous speed control both hoisting and lowering. When used for speed control, braking generators of the eddy current type, commonly called eddy current brakes, have some advantages over the more complicated d-c commutator machines. There is considerable literature describing the use of eddy current brakes in conjunction with wound rotor motors on elevator control.

Until recently, eddy current brakes had some undesirable speed-torque characteristics in that for a given excitation, the torque would pass through a maximum and decrease with further increase in speed. Engineers have succeeded in recent years in improving the speed-torque characteristics of eddy current brakes by ingenious choice of materials and rotor design. They have eliminated the drooping torque characteristic referred to above, thereby making the use of eddy current brakes on a-c crane hoists more nearly equivalent to d-c braking generators with external loads.

I should like to ask one or two questions:

1. The designation and coil of the brake relay are not incorporated in Figure 13. How is this relay tied in with the control?
2. What dictated the use of a permanent magnet alternator and rectifier in place of a d-c generator for excitation of the eddy current brake on power failure?

F. W. Wendelburg: In answer to Mr. Lucas' question on the last step lowering, this is a regenerative lowering step, the same as used on the last lowering control step on all other control schemes mentioned. The only braking action on this step is the braking or generator action of the motor being overhauled by the load. The slowest speed available on this step is synchronous motor speed at zero load. The slowest speed obtainable under load is above synchronous in amounts determined by the motor slip plus the amount of slip due to the permanent resistor in the rotor circuit of the motor which is generally around 10 or 15 per cent above synchronous speed at full load.

The next question Mr. Lucas answered himself. On

the first lowering step the motor primary is excited with the motor secondary open-circuited, the motor primary being excited only to release the motor brake. The motor brake is connected across the motor primary to avoid the use of additional bridge conductors to separately excite the motor brake. All the control of this step is accomplished by the overhauling load being retarded by the effect of the magnetic torque brake.

Leaving the controller on the first lowering control step should not damage the motor as the motor secondary is open-circuited. Under this condition the excitation current would be approximately 50 per cent of the full load motor current which should not be detrimental to the windings. The stall condition on the first lowering control step would only occur for loads from a range of 0 to 25 per cent load, all loads in excess of these loads would lower on this step.

Mr. Angel's question is on the cost of this control versus available conventional control. In comparison with load brake control, the cost of the control compares very closely, the magnetic torque unit offsetting the load brake cost. There is some addition in cost for magnetic torque control for the addition of such auxiliary equipment as transformer, rectifier, current relay and magnetic torque resistor.

The control is adaptable to existing cranes to replace the load brake. In most instances, especially on sleeve bearing cranes, it is necessary to mount the magnetic torque unit on the motor in place of the motor brake. In these cases the motor brake is removed and mounted on the motor coupling shaft, usually using a combination brake wheel and coupling, to couple the motor to the coupling shaft. With this arrangement, some of the safety features of the control are not available. On new cranes, the torque unit is mounted on the outside of the hoist gear case on an extension of the motor coupling shaft. In case of a motor shaft failure, the load will be slowly lowered by the retarding effect of the torque brake, preventing a free falling load. Therefore, on an old crane when the unit is mounted on the motor, this protection is not available.

With reference to the question on the excessive motor currents caused by rapid advancement of master switch from off to full-on position, this condition is no more severe with magnetic torque control than with any other full magnetic control scheme. Definite time acceleration, using pneumatic timers is used to time the accelerating contactors with full magnetic control. The timers are adjusted to automatically time the control steps if the master switch is advanced too rapidly from the off to the full-on running position in either direction. This automatically limits the inrush motor current.

There are two additional trolley wires required for excitation of the magnetic torque brake. The CR relay is a series relay connected in series with the torque brake winding. This relay interlocks the motor control circuit with the magnetic torque brake circuit, so that the motor circuit can only be energized after the torque brake is energized. Opening of the brake circuit would automatically open the motor circuit and set the motor brake on all magnetic torque control speed steps. We have tested the control by opening either a motor primary or secondary phase when operating the crane under capacity load and have found no condition of excessive lowering speeds.

Eddy current brakes have been used for some time to control speeds for a wide variation of applications, in most instances the control is in the form of a slip clutch. To our knowledge this is the first application of an eddy current brake used as a brake to preload the wound rotor motor for speed control on overhead traveling cranes.

The electric motor brake is excited by a step-down transformer and a selenium rectifier. A control relay closes and opens the circuit to both the line and load side of the rectifier. Excitation on the hoist motor governs the brake relay coil excitation. When the motor is excited, the brake relay coil is excited closing the brake circuit and releasing brake.

There are several reasons for selecting a permanent magnet alternator in preference to a d-c generator. A permanent magnet alternator does not require any brushes or sliding contacts and is, also, more compact, requiring less mounting space. As this alternator is only used in case of an emergency, for instance, in case of a simultaneous double failure of both power and motor brake, therefore, the elimination of brushes or sliding contacts is a decided advantage, insuring safe operation when required.

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MANDREL TYPE HOT STRIP COILER

By G. E. FARRINGTON
Chief Engineer
E. W. Bliss Co.
Salem, Ohio

. . . . the hot strip coiler described enables the operator to handle coils up to 20,000 pounds . . . .

▲ FOR years one of the greatest problems confronting hot strip mill operators has been the handling of strip after it has passed through the final finishing stand of the mill. The runout tables immediately following the last stand were of simple design, and based upon the work originally required of them, have performed satisfactorily as a whole. The coiling problem, however, has not been too successful in many installations—in that the equipment required too great an upkeep cost or that the length of strip or size of slab increased to limits beyond the capacity of the existing coilers.

Previous to 1938, hot strip coilers were either of two types. The blocking roll type consists of a group of motor driven rollers mounted on arms which are folded in to form a continuous circle about a solid mandrel or push-off beam. Guides placed between the roller deflected the strip to prevent the front end from passing between rollers. A small opening properly located admitted the front end to form the initial wrap. Throat pinch rolls of equal diameter were also employed to convey strip of light gage through the throat of the coiler from the table roll. As the coil built up, the blocker rolls were backed off in proportion to gage or build-up. As the weight of the coil increased, a disproportionately greater force was exerted on the bottom backing rolls. This feature caused trouble for the operators as the linkage had to overcome this pressure on the bottom plus enough force to friction drive the building up coil.

On the top the friction force only was required, and it was extremely difficult to properly adjust the total pressure to carry the coil as well as drive it, but not exert so much that the coil would be collapsed. Upon completion of the full coil, the rollers would be stopped and opened to their maximum position which lowered the coil until its center rested on the mandrel, or push-off beam. In addition, the driving of the building up coil by these blocker rolls tended to make a telescoped coal, as any misalignment of the blocker rolls caused the strip to travel either to the right or left, and the reaction on the inner wraps forced them in or out. A conventional pusher or stripper plate then shoved or ejected the coil onto a conveyor or upender. This type of coiler was limited in its tension, or pulling capacity, by the friction exerted on the coil and in the size of motors that could be applied to the driven blocking rolls. The pinch rolls, of course, could be designed with unlimited power, but the tightness of the coil depends to a great extent on the tension exerted by the coil in wrapping.

The paddle type coiler was of a much simpler design. A motor driven mandrel consisting of paddles was rotated and the lead end of the strip was fed into it. The end entered between paddles and as the mandrel or wheel rotated, the front end was doubled over and the first lap started. At high strip speeds this doubling did not always occur, as the front end could strike the end of a paddle, causing the strip to double in the throat and form a cobble. It was also necessary to match the periphery speed of the paddles with the strip in order to get a sufficiently good grip to provide tension on the initial laps.

Both of the above designs were subject to high maintenance from the beating given the rotating parts by the front or leading end of the strip, and in the case of the blocking roll type, also from the continual slip of the rollers on the coil when winding.

In 1938, a third type of coiler was introduced to the steel industry at a southern plant. This coiler, in our opinion, combined the good features of the two mentioned previously with the addition of a rotating mandrel and deflector pinch rolls. These two original coilers, plus a third delivered in 1946, have performed very satisfactorily, and formed a basis for the design of the 80 in. wide coilers put into operation early in 1948.

This third type of coiler consists essentially of a pair of unequal diameter deflector pinch rolls placed on the

Figure 1 — The end view of the coiler shows a partially wound coil on the mandrel.

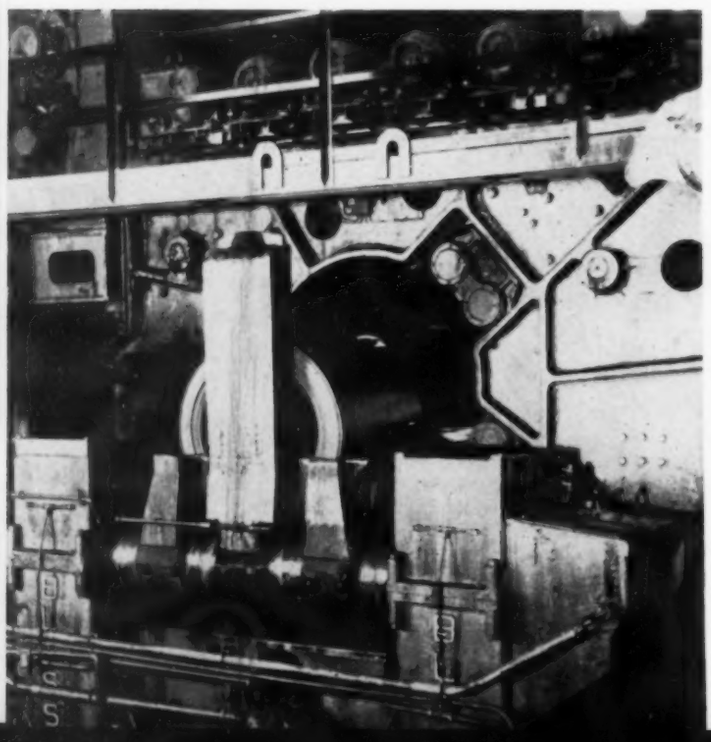
Presented before AISE Annual Convention, Cleveland, Ohio, October 1, 1948

table pass line just ahead of the gate or opening to the coilers. A throat or enclosed guide arrangement topped by the gate, leads the strip to the cluster of blocking rolls and mandrel. Four sets of motor driven blocking rolls surround a collapsible motor driven mandrel. The blocking roll carriages, of which there are four, slide in straight lines radially away from the mandrel. All four sets are linked together and are operated by two air cylinders. The mandrel is similar in design to a conventional cold mill tension reel, except that it always forms a circle whether expanded or collapsed, and has a greater diametrical difference between the expanded and collapsed positions than is usually found in cold mill reels. The collapsing process is performed by a rotating air cylinder. The mandrel is constructed of heat resisting steel and the four wedge segments and four arc segments are connected to the main shaft through a series of links.

Both the pinch roll and mandrel are connected to their respective motors through reduction units. The pinch roll unit serves both as a reducer and also as a pinion stand. Since both rolls are driven and each are of different diameter, the pinions are matched to this ratio. The larger roll is used on top as it serves to deflect the strip downward over the smaller roll, thus establishing a slight curvature on the leading end to aid in entering the material into the guide and onto the mandrel.

A 350-hp, 230-v, 575/1150-rpm, d-c motor drives the mandrel through a special reducer giving a top speed of 2500 fpm with weakened field and full voltage. Tension is maintained between the mandrel and pinch rolls or mandrel and finishing stand by two methods. A rotating regulator set limits the current drawn by the mandrel motor in much the same manner as a conventional cold mill reel. In addition, a motor driven rheostat starts when load is placed upon the mandrel motor and gradually increases the field as the coil builds up.

Figure 2 — In this view the upender has just taken the coil from the mandrel. The coil is automatically positioned so that it will be centered with respect to the conveyor chain.



The motor driving this rheostat is also of variable speed with its armature voltage set by the speed of the line, and its field is set by a small rheostat on the operating bench board. This small rheostat is calibrated in gages, the thicker ones giving more rapid movement of the motor operated rheostat and thus a more rapid slow down of the mandrel to compensate for coil build-up.

The two systems are tied together so that the operator can incorrectly set his rheostat for lighter gage or slow build-up and the rotating regulator will make the necessary corrections. The pinch rolls and blocking rolls are matched with the delivery speed of the last finishing stand by voltage regulation of the main generator. The blocking roll motors have a slight field variation set in the control house, and the pinch rolls can be modified by the operator if necessary. As an example of the operation, the ammeter on the bench board for the pinch rolls may read very close to zero while the mandrel may show 1000 amperes while the strip is still in the mill. As soon as the tail end leaves the last stand, the mandrel load remains the same, but the pinch roll reads minus 500 amperes, or is acting as a generator, thus maintaining tension throughout the entire coil. The mandrel and blocker rolls are started and stopped magnetically through armature acceleration while the running voltage is maintained at the generator for operation of the pinch rolls.

The mandrel motor and the four blocker motors are controlled, in normal operation, by one three-position master switch marked off—mandrel slow—mandrel and blockers run. Another point that has been of considerable interest to many is the means of stopping. The connected load is such that a graduated regenerative braking and dynamic braking scheme has been provided.

In the installation, a runout table, consisting of 268 rolls of 12 in. diameter, individually motor driven, was also installed at the same time as the coilers. The rolls are on 18 in. centers, and no apron plates are required.

The three coilers are placed in tandem on 22 ft-6 in. centers, discharging the coils to the right. All drives and driving motors are on the left side, as are the oil lubrication systems, electrostatic air cleaner, blowers, and sump pumps.

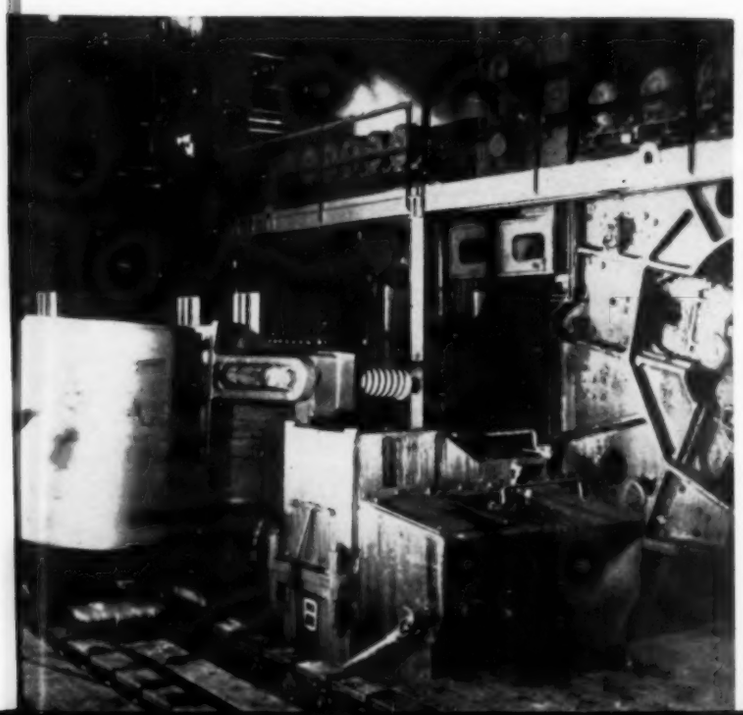
The deflector pinch rolls are mounted on anti-friction bearings encased in chocks similar in design to mill roll chock assemblies. In order to get deflection from each pair of pinch rolls, it was decided to make the top roll 36 in. in diameter, and the bottom one 20 in. The bottom roll chocks rest in the housing windows in like manner to a two-high mill, while the top chocks are raised and lowered by means of a pneumatic cylinder. A crown of ¼ in. on the diameter was placed on the top roll to facilitate centering the strip. Both rolls are driven through a special pinion stand with universal spindles by a 200-hp, 230-v, 875/1150-rpm, d-c motor. The four sections of table are each driven by their own generator and thus strip speed can be accurately controlled for each section. The group of ten rolls over No. 1 coiler and ten over No. 2 coiler can also be stopped and started separately from the remainder in the section by means of magnetic control. The rolls over No. 3 coiler are driven from an existing variable frequency alternator as they convey sheets to the piler only.

The table rolls are of cast iron with cast steel hubs and short shafts mounted on anti-friction bearings. Direct current motors were used to drive the table and speed variation is obtained by voltage control of the motor-generator set generator attached to each of the four sections. Each roll and motor is mounted as a separate assembly, and can be replaced by removing a total of four bolts and one disconnecting plug. Motors are individually protected electrically from field or armature over-currents. The bearings are automatically lubricated from a central grease system which also lubricates the side guide ways.

The entry side guides are adjustable by means of a master switch on the coiler operating bench board, and the exact width is indicated in the pulpit by a scale graduated in inches from 8 to 80. This reading or indication is transmitted electrically from a small d-c transmitter geared to the side guide adjustment drive to a d-c receiver geared directly to the scale. Power failure or shut-down does not affect the reading as the receiver automatically adjusts itself to the correct position when current is again restored. The guides are slightly sloped from the vertical so that a wedging action is imparted to the strip entering the pinch rolls. This slant on the guides serves to automatically aid in centering the strip in conjunction with the crown on the pinch rolls. The slope or slant on the guides was used only on the short parallel section ahead of each pinch roll, and not on the bell mouth or approach guides.

The strip enters between the set of two rolls at nine o'clock and the set at two o'clock. The remaining sets at five and seven o'clock also serve to guide the front or leading end of the strip around the rotating mandrel in much the same manner as a conventional type belt wrapper. Each of the four sets of 13 in. diameter by 80 in. face blocking rolls is driven by a 40-hp, 230-v, 1150-rpm, d-c motor through gearing on the opposite side from that shown here. The mandrel in the expanded position is 32 in. in diameter and 80 in. long, and collapses to 31 in. by means of an air cylinder. No thrust load is imparted to the supporting bearings as the entire thrust load in either the expanded or collapsed position is kept within the shaft itself.

Figure 3 — The coil is shown being deposited on the center of the conveyor chain.



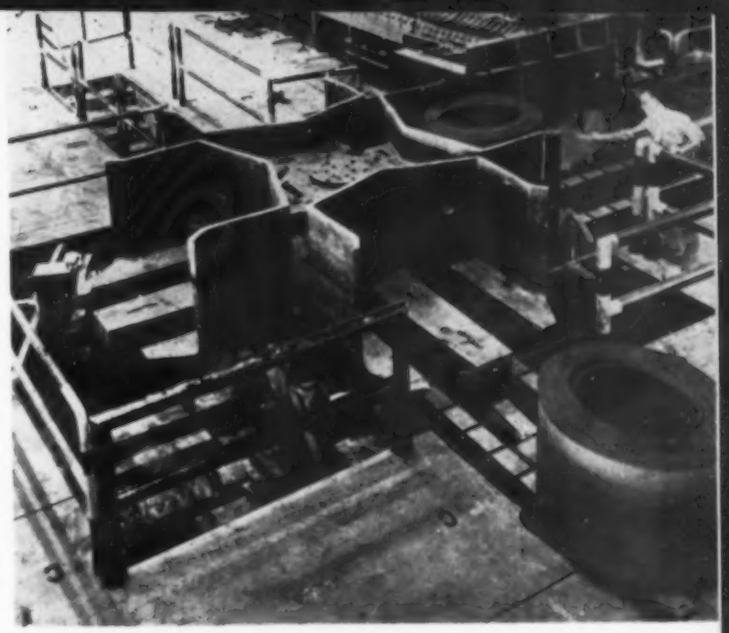


Figure 4 — In the "Whirlie" the coils are lifted from one chain and deposited on another chain running at right angle without slippage between chain and coil edges.

The spray is manually controlled by the operator, as are the blocking rolls, stripper, gate, pinch rolls, block collapse and speed control. The various movements are interlocked electrically, and the controls can be preset by the operator so that starting the series of the master is all that is required.

As the block is collapsing, the slots of the arc segments draw together. The wedge segments combine with the arc segments to form a smooth continuous block surface around the circumference and for the full 80 in. of face. The blocker rolls are moved in and out by two 26 in. diameter by 24 in. stroke air cylinders which are connected to a common system of linkage, controlling each set in unison with the other three. The stripper is actuated by a double acting 16 in. diameter by 137 in. stroke air cylinder. The block cylinder is 18 in. in diameter by 3 in. stroke, and is mechanically connected to an interlocking limit switch which indicates to the operator the block position as well as prevents coiling on a collapsed mandrel. All moving parts are mounted on anti-friction bearings with the exception of the main block or mandrel bearing, which is an o'l bearing. All bearings are either grease or oil lubricated from one of the five systems on the three coilers. The bench board controls the coilers and tables only and the upenders, conveyors, and waffle tops or coil hoists are operated from a separate station at conveyor level.

The upender consists of a cradle mounted on two double worm reducers which are driven by a 75-hp mill type motor. A brake and rotary limit switch control the upending action using dynamic braking at the end of each movement. The start of the tilting action is controlled by limit switches to prevent interference, but the upender operator also has a switch which permits tilting. The upender as a unit is mounted on a six-wheel

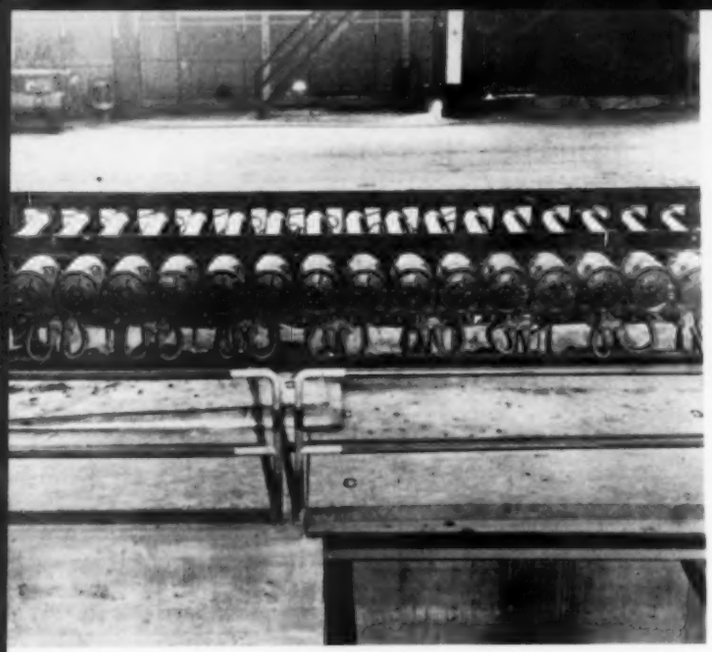


Figure 5 — The driving motors are here shown in the general view of the runout table.

car and is traversed by two 12 in. diameter by 144 in. stroke air cylinders controlled also by the upender operator. The single arm on which the coil rests for depositing on the coil hoist contains a sliding member for automatically centering the coil with respect to the conveyor chain. This moveable portion is connected to a pair of hydraulic cylinders supplied from a continuously running pump. A cam operated valve admits and exhausts the oil pressure. A stationary lug mounted on the arm stops the inside of the coil in the proper location, thus assuring accurate centering no matter what size coil is rolled. The coil hoist, controlled from the upender bench, is merely a hydraulic ram with guide rods to prevent rotation. Limit switches prevent its rising if the upender is not in the correct position, and prevents return of the upender if the hoist has not risen. The three hoists are fed from a common hydraulic source, and are operated by double solenoid four-way valves. No sliding of the coil on its edges takes place, thereby eliminating trouble for the pickler operators and loss of material.

The coil is transported on its edge to the scale and from there to what we term a "whirlie." There are two chains in this installation, one travelling east and one west.

The whirlie consists of four cradles mounted on a hydraulic ram and rotated by a combination helical and worm gear unit driven by a 10-hp mill type motor. A rotary limit switch permits turning 90 degrees only, and at present the ram is being controlled manually by an operator. The coils are lifted from the chain and redeposited on the other chain without slippage between chain and coil edges. From here the coils pass to a downender, where they are carried by crane for storage.

This equipment has handled 406 tons in one hour, 2644 tons in eight hours, and coil weights up to 20,000 lb. Stainless as well as low carbon has been coiled. We feel the installation to be far less troublesome than any in service today, and since trouble is money, this type is cheaper to operate and maintain.

DISCUSSION

PRESENTED BY

R. A. GEUDER, Manager, Applied Engineering Department, The Reliance Electric and Engineering Co., Cleveland, Ohio

E. O. REESE, Assistant Superintendent, Hot Strip Mill, Youngstown Sheet and Tube Co., Campbell Works, Youngstown, Ohio

G. E. FARRINGTON, Chief Engineer, E. W. Bliss Co., Salem, Ohio

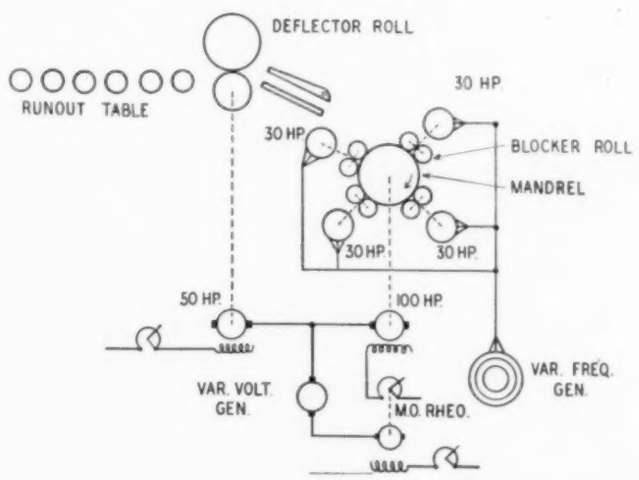
R. A. Geuder: The steel mills who already have or are about to install this type of coiler, and the plants which are constantly reaching out toward solutions to reduce cost and increase production, this mandrel type coiler may be the answer to the hot coiling problem.

Certainly, it appears to make progress toward the art of handling larger coils—19,000 lb to date—as compared with the usual 8000 to 10,000 lb coil previously considered normal. The first installation used 100-hp motors on the mandrel, 50-hp motors on the deflector roll, and 30-hp motors on the blocker roll. The use of d-c, table runout table motors had not yet proven itself, so therefore, the blocker rolls were a-c motors while the mandrel and deflector roll motors were d-c.

Figure 6 shows the general arrangement. Incidentally, some coilers being changed over now are using a similar arrangement.

The mandrel motor has sufficient field control to compensate for the coil build-up, usually a little over 2:1. Note that the lineal speed of the coiler is set by the voltage from the variable voltage generator and that

Figure 6 — The general arrangement of the first hot strip mandrel coiler is shown in this sketch.



the variable frequency alternator follows the variable voltage generator. Moreover, the motor of the motor operated rheostat gets its armature power from the same source of variable voltage so the primary speed of the motor operated rheostat matches the lineal speed of the coiler. Field control of the motor operated rheostat compensates for gage since light gages build up at a slower rate than heavy gage material.

The technique of operating a mandrel type coiler was unknown in the first installation. Operators did not know whether the deflector pinch rolls would be open or closed. In the event the deflector pinch rolls are open, we lose any speed reference after the strip has left the mill. Hence, the motor operated rheostat control was furnished for the mandrel motor field.

If the deflector pinch rolls are closed, the deflector roll motor may act as a generator and has a vernier field control rheostat to get the proper load on it.

The second installation, Figure 7, has a much larger capacity and the motors are, of course, greater in size. It has capitalized on the knowledge and experience gained from the earlier units. Here the deflector roll motor is 200 hp, the mandrel is 350 hp and the blocker roll motors are 40 hp. All motors are d-c shunt wound units.

Note that in addition to the motor operated rheostat similarly used on the first installation, a rotating type current regulator is superimposed on the field of the mandrel motor. If the deflector rolls are closed the regulator can control current and consequently, tension. Moreover, if the motor operated rheostat is used with the deflector rolls closed or open, the regulator can act as a current limit or safety valve.

IR drop compensation is not considered necessary because the operating voltage range is not in excess of approximately 3:1. The blocker roll motors should be well matched with the deflector roll motor so that the initial wraps on the mandrel will be snug. Since the mandrel motor is stopped to discharge a completed coil, it is designed with a minimum WR^2 to assist in rapid acceleration in order to be ready for the next coil.

The operating technique still is not crystallized. Some power readings on this mandrel type of coiler taken from two different installations are anything but consistent except that they are consistent in making good coils. It seems as though the operators can choose a wide variation in the way they put power to the strip. For instance, on 0.047 steel, 30 in. wide, at 1700 fpm, one mill is using roughly 100 hp, whereas another mill on 0.060 steel of the same width is using about 350 hp.

Some readings on gages up to 0.189 show coils are being successfully made at 1600 fpm with about 100 hp.

Horsepowers on the mandrels have ranged from 100 hp on the original installation to 350 hp on one which is just going into service. There are some more being installed with 250 hp on the mandrels. When a few more are installed and being operated, the technique will be improved and there will be a good cross-section picture to report.

E. O. Reese: A great deal of the progress of the steel industry can be accredited to research and development work, such as was necessary to produce this coiler. Mr. Farrington has given us an outline of the history of hot strip mill coilers with a good description of the blocking roll and paddle types which are commonly in use at the present time. I believe I am safe in saying that most strip mill operators have a good working knowledge of the shortcomings of these two types of coilers and are very happy to be able to learn more of any new and improved types of coiling equipment.

Mr. Farrington's description, along with the pictures, has given us a good general idea of the construction and operation of the mandrel type coiler and, as a result, certain questions that are of prime importance to hot and cold strip mill operators are brought to mind.

First, how effective has the mandrel type coiler been in reducing mill delays due to head ends "sticking?" In this case, I am thinking in particular of the head ends encountered in hot strip mills that do not crop before entering the finishing stands, and as a result, have a certain amount of "ears" or "fishtails" on the head ends.

G. E. Farrington: I cannot give any exact production figures. However, I can say this, that any coil that has gone from the mill to the pinch rolls has been coiled, whether it is cropped or not.

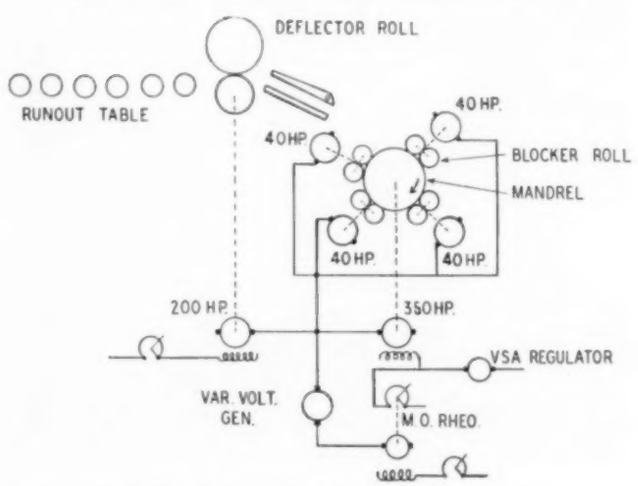
E. O. Reese: How successful has this coiler been in eliminating the telescoping that has been such a problem with the older type coilers?

G. E. Farrington: I believe it has solved the telescoping problem. As I tried to point out in the paper, any slight misalinement to 90 degrees of the strip by the blocking roll would tend to form the coil with the center working either to the right or to the left. On a cold mill reel, and that is all this hot mandrel is, the strip can be cambered on the front end. The first few laps on the reel can telescope and since the distance from the pinch rolls to the mandrel is constant, it can only run over so far and from then on there will be no telescoping. Perhaps the first two or three laps may have two or three telescopes, but from then on there should be none.

E. O. Reese: I would like to know the maximum load in pounds per inch of width that the coiler has handled successfully.

G. E. Farrington: I have seen coils coiled that weighed 19,800 lbs, and I believe they were 42 in. in width. The coiler is designed to take a maximum diameter of coil of 64 in., and 76 in. is the maximum width of this strip. I cannot give you the exact pounds per inch.

Figure 7 — The motor sizes in the second installation had a greater capacity than those shown in Figure 6.



American Steel and Wire Company

OPENS STAINLESS DIVISION AT WAUKEGAN

▲ AN entirely new mill designated as the Stainless Steel Division, and equipped exclusively to process rounds ½ in. and smaller and certain sizes of flat stainless steel wire on equipment designed specifically for the purpose, has been built and placed in operation at the Waukegan, Ill., works of American Steel and Wire Co. The objective of operations is to produce quality stainless steel wire in quantity, and this plant, having a rated capacity of 500 tons per month, is one of the largest stainless steel wire producers in the country. All equipment is so geared in power that it will be possible to increase the rated capacity greatly without the addition of much equipment.

Rod storage—Raw materials for the new mill are rods received primarily from the Joliet, Ill., plant of American Steel and Wire Co. The latter plant's supply of stainless steel billets is produced at the South Chicago works of Carnegie-Illinois Steel Corp. A revolving, tilting crane has been provided for the rod storage inspection area and the storage bin. The normal flow of material is to unload the car and deposit the rods in racks adjacent to the inspection and welding area from which they move to the rod storage bins.

The rod inspection area is equipped with several storage racks; two jib cranes and hoists; flash welders; pointers; upset testing machine, and bundle compressor. Here the rods are individually inspected, welded end to end into 500-lb parcels and compressed into a neat package for efficient handling in the ensuing annealing operation. In detail, every bundle is given a visual examination for surface defects. Upset tests are made. A second coil is inspected and, if satisfactory, is welded to the first, using the flash welder. This equipment is new to the stainless wire industry but preliminary tests have indicated that most stainless steels can be welded satisfactorily. As the rods are received they are welded and either sent to storage or to the annealing department for treatment prior to drawing. The bundle is weighed and the weight recorded on the ticket and the duplicate roll tape. Proper designating numbers are used for establishing heat and type identification on each 500-lb bundle.

Rod storage bins—Twenty-six bins have been provided for storage of at least five hundred tons of stainless steel rods. Two 1000-lb bins are stocked at one time, records being kept of exact weight of rods held in storage.

Rotary hearth annealing furnaces—One ton of rods consisting of two 1000-lb packages is brought to the annealing department by the rod storage crane. This load is split into two 1000-lb charges for the annealing furnaces by the overhead crane operated in conjunction with upending machines. These machines are provided for the main purpose of flipping the vertical bundles into a horizontal position so that they may be readily handled by the fork tractor which charges the rotary annealing furnaces. These upenders are operated by the cranemen in both the rod storage and cleaning house cranes.

After the 1000-lb bundles have been flipped into horizontal position, they are ready to be charged into the furnace. The furnace man or helper who is operating the tractor removes the charge from the upending machine and then backs away and approaches the door of the annealing furnace. This door is operated electrically and automatically opens when the tractor is approaching. The operator is thus in a position to concentrate on placing the charge neatly in the annealing furnace.

A bright tracery of light marks a "first" as the inspector-welder watches an electric weld of two coils of stainless steel rods. In a process new to the industry, the 175-lb coils of 5/16 in. rod are flash-welded together to make larger bundles. Later on, this will cut down time in drawing the stainless steel wire continuously.

When the predetermined cycle is completed, the operator again approaches the furnace door, which automaticaly opens, obtains the hot bundle from the furnace and deposits it upon the quenching platform located above the quenching tanks. By this time the furnace door has automatically closed again. The operator upon backing away from the quenching tank causes the charge to be lowered into the quenching solution. This operation is completed as rapidly as possible to obtain maximum softness for the austenitic grades of steel and to prevent any carbide precipitation. An automatic timer has been provided for the elevator mechanism so that it will automatically raise the charge to working level at the completion of the quench. The bundle is then placed back upon the upending machine.

Annealing department equipment—There are two large and one small rotary annealing furnaces. All can be operated at 2100 F. All are controlled from a common control house located at the north end of the department. The large furnaces may be operated in any one of three different ways. The most predominant will be the continuous treatment, whereby 1000-lb package will be charged periodically, resulting in an approximate capacity of 4000 lb per hour for each large furnace. In this operation, the furnace temperature is 2100 F throughout the cycle. The second manner in which the furnaces will be operated is a batch method, whereby the entire furnace will be charged with cold steel, brought up to temperature and cooled at a definite rate until the proper discharge temperature is reached. This method applies only to the martensitic and ferritic grades of stainless steel. The third method is somewhat a repetition of the first. Furnaces may be zoned so that steel is subject to certain temperature requirements as it passes through the furnace. This applies primarily to ferritic grades. The small furnace was so planned that special steel, experimental cycles and small lots can be handled without interfering with the operation of large units. It will also batch anneal finer gages of wire.

The quenching tank is equipped with a heat exchanger which prevents the solution from becoming too hot. Temperatures from 40 to 180 F will provide equally effective results.

Cleaning house—A stainless steel cleaning department is quite different from what the carbon steel wire industry commonly calls the cleaning house. This is entirely due to the multiplicity of cleaning operations required. Equipment installed includes tanks for muriatic, sulphuric, and nitric-hydrofluoric acids. Quenching, spray, and coating tanks have been provided for water; and for copper, lime and other wire coatings. Cleaning is performed in an electrically heated salt bath furnace.

In summary the cleaning has its use for the following purposes:

1. To prepare rods and wire for drawing by the oxide process.
2. To clean, passivate and lime coat rods and wire for finish drawing.
3. Activate material for metallic coating.
4. Copper coat wire for final drawing to customer specifications.
5. Strip metallic coating.
6. Degrease.

One thousand pounds of red-hot stainless steel rods are removed from one of the new rotary hearth furnaces. The furnaces, heated to about 2000 F, are controlled electrically and used to heat treat stainless rods, preparing them for drawing into wire.

Acid handling—To accomplish the various functions in the cleaning house, it is necessary to utilize different acids, namely: muriatic, sulphuric, nitric, and hydrofluoric. The muriatic (hydrochloric) is used for activation; the sulphuric for neutralization; and the nitric-hydrofluoric for passivation. All of the acids are handled in carboys.

Wire drawing—Due to the complexity of stainless steel requirements, wire-drawing equipment has been set up to produce many different finishes.

All coarse-wire drawing equipment is variable speed. This feature has been incorporated for several reasons: (1) actual optimum wire drawing speed for stainless steel is variable; (2) maximum flexibility is required; and (3) due to the wide range of sizes it is expected to produce, it would have been necessary to have over twice as much machinery if set, constant speed units were installed.

Coarse-wire drawing equipment includes the following machines:

1. Two heavy-duty 100-hp motor blocks
2. Eight medium-duty motor blocks
3. Four four-draft continuous machines
4. One six-draft continuous machine

Auxiliary equipment includes flash welders, rod butt welder, a wire butt welder, four rotary swaging machines, six roll pointing machines, three flipper reels, twenty-eight miscellaneous revolving reels, and twelve 1000-lb electric hoists.

Heavy-duty motor blocks—The two vertical-spindle, heavy-duty motor blocks are equipped with 26-in. and 30-in. interchangeable blocks and strippers. The blocks

and die-holders are water cooled. They are driven with 100-hp, d-c three-to-one speed range motors, which results in a block speed varying between 17 and 51 rpm. Thus, when using 26-in. blocks, these machines have a speed range of 115 to 345 fpm. These two machines form one work station.

Medium-duty motor blocks — Eight medium-duty motor blocks are equipped with speed indicators. Two rotary swaging pointers are provided for sizes 0.200-in. and coarser, and two roll pointers for sizes 0.250 to 0.0625-in. Like the heavy-duty motor blocks, these machines have water-cooled blocks and die holders. For flexibility, four machines are equipped with 26-in. blocks; three have interchangeable 22 and 26-in. blocks; and one, 22-in. and 16-in. interchangeable blocks. These units are powered with 50/60 hp, d-c three-to-one variable speed motors, which result in speeds of 44 to 72 rpm. Thus, the available speed range for 26-in. blocks is 162 to 499 fpm; on 22-in. blocks, 138 to 414 fpm; and, lastly, on 16-in. blocks, 101 to 303 fpm. The stripping capacity is five hundred pounds for 26-in. blocks; 400 pounds for 22-in. blocks; and 300 pounds for 16-in. blocks.

Four-draft continuous machines — The four four-draft continuous wire-drawing machines are likewise equipped with different sizes of finishing blocks. Primarily, the process wire is wound on 26-in. blocks and two machines are so equipped; three have interchangeable 26-in., 22-in., and 16-in. blocks so that it is possible to use these machines as wire processing units. All blocks are air and water cooled and die boxes are also water cooled. Each spindle of each machine is driven by a separate three-to-one speed range, 25-hp, d-c motor. This results in finishing speeds of 200 to 600 fpm using the 26-in. block; 169 to 507 fpm using the 22-in. block; 123 to 369 fpm using the 16-in. block. Stripping capacity handles 300-lb bundles for the 16-in. blocks; 500-lb bundles for the 22-in. and 26-in. blocks. These machines are designed to finish wire from 0.062 to 0.150-in. diameter. In one machine, the blocks may be used singly or in pairs, thus providing a unit similar to a bench.

New stainless steel wire drawing blocks employ vertical motors, require less floor space than old types. Two on the end are called "bull-blocks" for heavy duty, and eight in the foreground are for medium wire. All are water cooled and equipped with speed indicators to guide drawing speeds.

Six-draft continuous machine—The six-draft continuous wire drawing machine is quite similar to the four-draft units and the same features are incorporated. This machine will finish on 16-in. blocks having a capacity of 300-lb bundles. Each spindle is driven by separate three-to-one speed range, 15-hp, d-c motor which results in finishing spindle speeds of 250 to 750 fpm. The machine is designed to process wire having a maximum size of 0.150-in. and finishing 0.080-in. and finer.

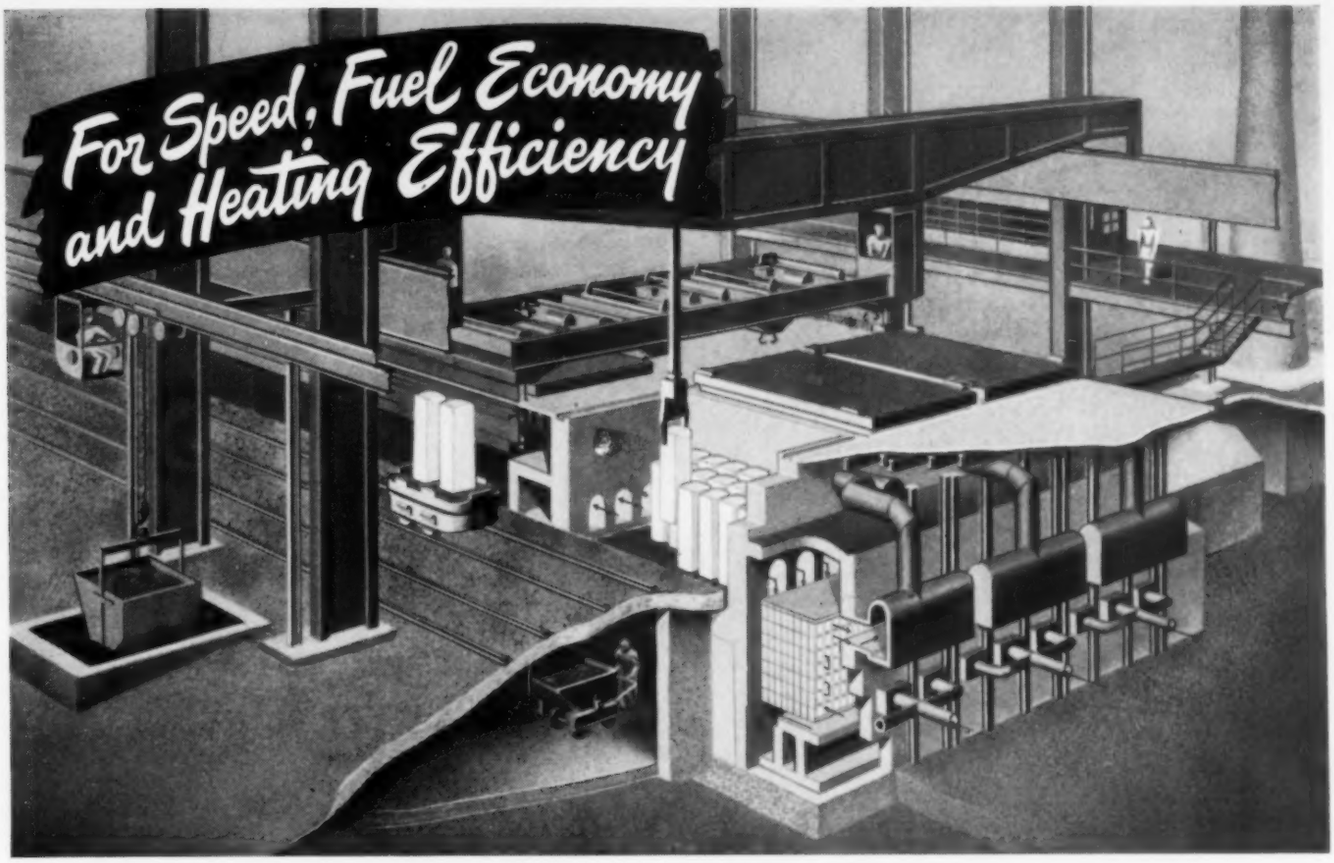
The equipment incorporated in the fine-wire drawing department is as follows:

1. Five 8-draft, 8-in. and 12-in. finishing block machines having fixed reductions between drafts for proper stainless practice. The finishing block has a variable speed of 300 to 900 fpm, and is capable of finishing wire to as fine a size as approximately 0.020-in.
2. Ten 12-draft wet-wire machines complete with spooling attachment. These units are also capable of finishing 8-in. coils. Each machine has a maximum speed of 2000 fpm with an expected operating speed of 500 fpm. These are used for drawing wire as fine as 0.004-in.
3. One 10-wire, 5-draft tandem machine. This machine has a speed ranging from 100 to 400 fpm, and is capable of finishing on spools only.
4. Three 16-draft machines, which are used primarily for drawing very fine wire.

Fine-wire bright annealing—All fine stainless steel wire shipped in the annealed condition is continuously bright annealed. A 30-wire unit has been installed for the bright annealing of fine wire. Up to a set size range, speeds may be increased to keep capacity at a uniform rate. This equipment is furnished with spool-handling facilities for both the pay-off and take-up ends. The furnace itself is electrically heated by means of non-metallic resistor elements. Tubes through which the wire passes are made of inconel to withstand the high temperatures involved. An atmosphere of dissociated ammonia is employed, which is really a mixture of hydrogen and nitrogen. Care is taken at all times to insure proper working conditions, as even a slight amount of air or moisture in the tubes will cause the production of tarnished wire.

A second unit is a 14-tube furnace and was installed to bright anneal the coarser sizes ranging from 0.030-in. and up to 0.090-in. This unit has been equipped with cranes, reels, and a conventional strand takeup as auxiliary equipment.

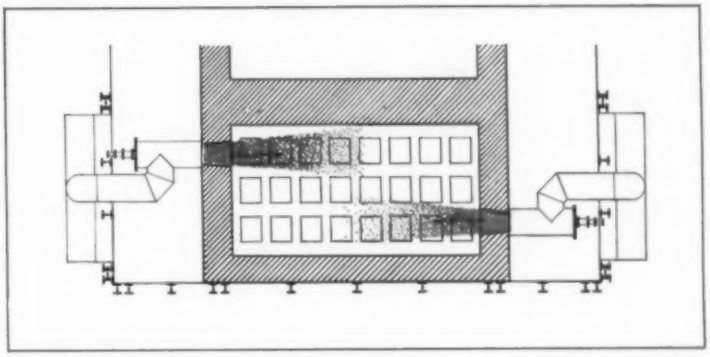
Strand annealing—A 12-wire strand annealer has also been installed. Most annealing will be performed in the

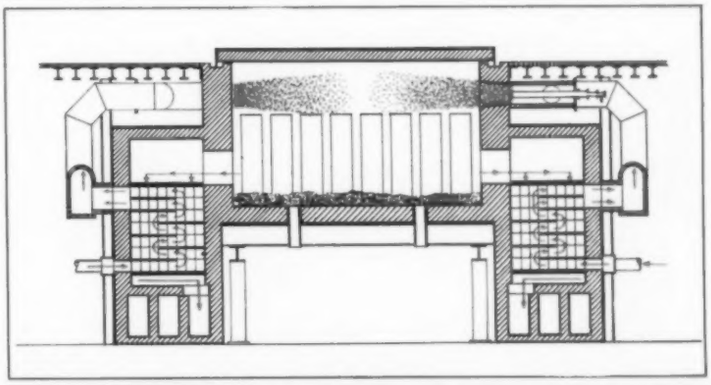


RUST CONTINUOUS-FIRED SOAKING PITS

Two-way top fired ▲ Completely automatic ▲ Recuperative type ▲ All fuels

THESE ULTRA MODERN SOAKING PITS provide increased efficiency, increased economy and greater charging capacity per sq. ft. of area. By diagonal two-way firing the heat is distributed uniformly throughout the pit and on cut backs both ends of the pit remain in balance thus ingots soak out evenly. Absence of impingement increases life of refractory walls and covers. Design permits construction in batteries of two or more holes.





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ONE RUST CONTRACT covers everything . . . from blueprint to test-run. Rust assumes responsibility for design, manufacture and erection of all essential material . . . including excavations, foundations, wiring and piping. Your purchasing and engineering departments are freed of subcontractor headaches when you order from Rust.

RUST FURNACE CO.

PIONEERS IN FURNACE DESIGN

PITTSBURGH, PENNSYLVANIA

On five, eight-draft machines, medium sized wire from 0.030 to 0.060 in. in diameter is drawn to either finished wire or processed wire for further drafting. From these wire drawing machines come stainless steel spring wire, armature binding, rope and weaving wire and wire for processing into very fine sizes.

batch rotary annealing furnaces, and the installation of this equipment merely aids in processing special products for various requirements, such as martensitic grades of stainless steel.

Tin coating—Stainless wire is primarily tin coated for armature binding wire. The tin is not applied as a protective coating but acts primarily as an aid to automatic soldering by the user. It is the practice to tin and spool in one operation.

The equipment consists of cleaning, washing, and flushing tanks; gasfired tin melting furnace and conventional spool and takeups. A feature of the spooling takeup is the fact that torque motors are employed, making it possible to operate at predetermined tensions.

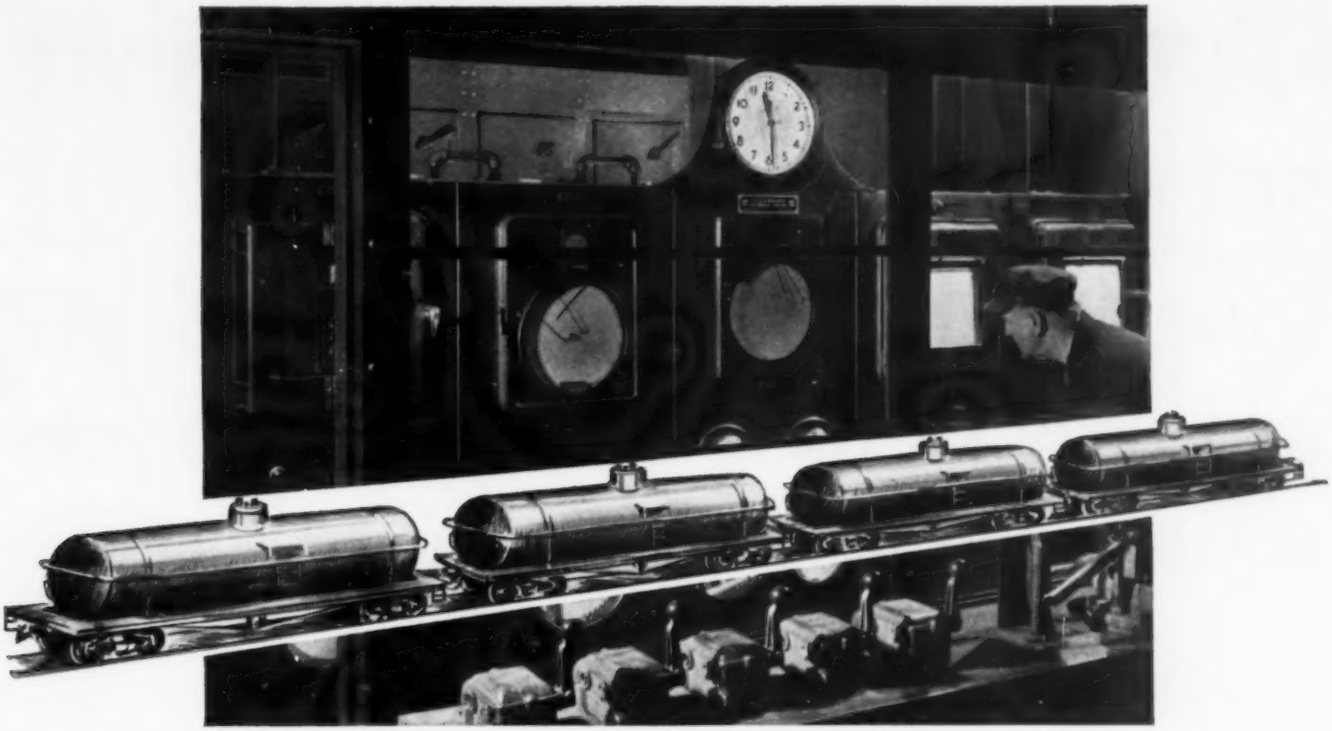
Straightening and cutting equipment—Three wire cutting machines have been provided for cutting $\frac{1}{16}$-in. to $\frac{1}{2}$-in. wire, to meet requirements that various types and finishes be straightened and cut. These include soap and grease drawn wire.

Cold rolling—Considerable tonnage of flat wire will be made from a process round wire. Two new cold-rolling machines complete with all necessary facilities have been provided. One is an 8-in. machine and the other a 6-in. machine. A product such as cotter-pin stock will be made on this equipment. Provision is made so that wire can be given one, two, or three passes through the rolls to obtain an ultimate quality product. It is important that all process wire be accurately gaged so that the final product meets user specifications.

Tentative List of Papers Scheduled for AISE Annual Convention

HOTEL WILLIAM PENN, Pittsburgh, Pa. **October 3, 4, 5 and 6, 1949**

Controls for Combination-Fired Boilers
Open Hearth Furnace Control
Experience in Oxygen Flow Measurements
Heating Rounds Prior to Rolling
Construction and Maintenance of Open Hearth Bottoms
Checker Design
Design and Maintenance of Crane Runways
Sliding Contacts for Transfer of Electrical Energy for Industrial Systems
Design and Construction of Ore and Coal Bridges
Supervisory Control and Telemetering
Characteristics of Magnetic Amplifier
Mechanical Rectifier Operation
Standardization Reports
Crane Wiring Specifications
Design of 600 Series Mill Motor
Cold Rolling of Tinplate
The Action of Cutting Fluids in Machining
Steel Plant Lubrication Training
Evaluation of Oil Filters
Oil Seals
Bearing Inspection and Repair
Roller Bearings
Roll Design for Angular Sections
Roll Lubricants
Operation of Continuous Merchant Mill
Maintenance Welding in Steel Plants
Couplings for Rolling Mill Drives
Painting in the Maintenance Program
Developments in Coil Conveyor Equipment
Materials Handling in the Steel Plant
Relationship of Material Handling to Production
Reviewing Progress in Pressure Blowing Blast Furnaces
Rapid Charging of Open Hearths
Continuous Galvanizing



4 TANKERS OF OIL FREE—EACH MONTH TO THIS USER OF L&N O-H CONTROLS

About four years ago one of the big steel mills installed L&N automatic controls for roof-temperature and for furnace pressure on their 175-ton open-hearth furnaces. The furnaces had operated on Manual Control — and were good producers, making 8500 tons of steel per month at satisfactory cost figures. But the company engineers decided that this new instrumentation would save more than enough fuel to justify the improvement.

Just how right these engineers were is shown by the fact that the instruments save four to five gallons of oil per ton of steel — which adds up to four cars per month — or enough oil to pay for the instrumentation every four and one half months!

Furnaces Always Well Handled

This showing is all the more significant because the furnaces have always been handled with skill — before and after automatic control was adopted. The First Helpers in this plant are steel-making experts who would be more than welcome in any mill. Backing them up is an outstanding metallurgical department, and the Company (sorry, can't name it here) is one of the biggest, with a long-standing name for fine steel. In other words, these instruments were not facing a straw man — they had to beat the very best that expert personnel and fine furnaces could do under Manual Control. And the instruments succeeded.

Other Costs Go Down

Furnace "campaigns" are longer, because the roofs (usually the first structural part to go when a furnace needs rebuilding) are protected against overheating. There's a slight but noticeable improvement in the manhours-per-ton ratio. Instruments operate continuously and unfailingly, with only scheduled maintenance at customary intervals.

Panels By L&N Cut Installation Cost

Control panels were designed and built by L&N; shipped with all connections in place for every item on the panel. Each panel is in effect one huge instrument for making more steel at lower cost.

Details of these and other L&N instruments for open-hearth control will be sent on request. Address Leeds & Northrup Co., 4942 Stenton Ave., Philadelphia 44, Pa.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Irl Ad N-643(9)

"During a power phase failure not one motor out of over 100 failed to clear itself . . . When power was restored we were ready to operate without a moment's loss in production"

"We believe you will be interested to know how well your Fusetron dual-element fuses protected our electric motors when we experienced a phase failure on our power circuit this past week.

"We have considerable obsolete 2 phase equipment in our plant but we are eliminating it as we go along. To protect these motors until the change-over, we had two choices: expensive thermal relays or Fusetron fuses. Naturally, we chose Fusetron fuses. From that time on, which is over two years, we have not lost one motor. Last week when the power phase failure occurred, not one motor failed to clear itself.

"Having over a hundred motors in the plant, we had a hatfull of blown fuses to replace but, when the power was restored, we were ready to operate without a moment's loss in production.

"Our past experience with Fusetron fuses proves that they will not blow needlessly — provided, of course, that the fuse rating is matched to the motor.

"We are using Fusetron fuses on our new machinery along with thermal protectors to prevent the machine operators from blocking the relay switches in the on position.

"Fusetron fuses are an absolute must on all electrical equipment in our plant."

Victor J. Kryst, *Maintenance Foreman,*
F. H. HILL COMPANY, INC.,
Cleveland, Ohio

Our Experience . . . Proves

Facts About FUSETRON Dual-Element FUSES

The fuse link element opens on short-circuit — the thermal cutout element protects on overloads — the result, a fuse with tremendous time-lag and much less electrical resistance.

They have the same degree of Underwriters' Laboratories approval for both motor-running and circuit protection as the most expensive devices made.

Made to the same dimensions as ordinary fuses — fit all standard fuse holders.

Obtainable in all sizes from 1/10 to 600 ampere, both 250 and 600 volt types. Also in plug types for 125 volt circuits.

Their cost is surprisingly low.

(FUSETRON is a trade mark of the Bussmann Mfg. Co., Division of McGraw Electric Co.)

Fusetron DUAL-ELEMENT Fuses

Provide

10 Point Protection

1. Protect against short-circuits.
2. Protect against needless blows caused by harmless overloads.
3. Protect against needless blows caused by excessive heating — lesser resistance results in cooler operation.
4. Provide thermal protection — for panels and switches against damage from heating due to poor contact.
5. Protect motors against burnout from overloading.
6. Protect motors against burnout due to single phasing.
7. Give DOUBLE burnout protection to large motors — without extra cost.
8. Make protection of small motors simple and inexpensive.
9. Protect against waste of space and money — permit use of proper size switches and panels.
10. Protect coils, transformers and solenoids against burnout.

Get all the Facts - Send the Coupon Now!

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TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS

FUSETRON Dual-Element Fuses Give ALL-PURPOSE PROTECTION

One needless shutdown — or one lost motor — or one destroyed switch or panel — may cost you far more than replacing every ordinary fuse with a FUSETRON dual-element fuse.

Don't risk such losses — protect yourself by installing a FUSETRON dual-element fuse in every set of fuse clips throughout the entire electrical system.

Bussmann Mfg. Co., University at Jefferson
St. Louis 7, Mo. (Division McGraw Electric Co.)

Please send me complete facts about FUSETRON dual-element Fuses.

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GENERAL REFRACTORIES' NEW LABORATORIES TO AID RESEARCH

▲ Located on the grounds of the company's largest manufacturing unit, the new Baltimore research and development laboratory of General Refractories Co. is dedicated to the improvement of refractories. It is equipped to perform exhaustive physical and chemical tests, and contains facilities for research into basic principles from which refractories of higher and higher quality will be developed, for testing the adaptability of refractories to every sort of process and furnace construction, and for performing continuous control tests on all phases of refractories production.

The general plan of the laboratories contains two units: a single-story brick and concrete building containing offices, library and facilities for basic research, and a steel and glass factory type structure containing complete facilities for developing and testing refractory products.

The first building (A) contains a well-equipped analytical chemical laboratory which is also provided with the facilities for determining such properties of refractories as true specific gravity, bulk density, porosity and permeability.

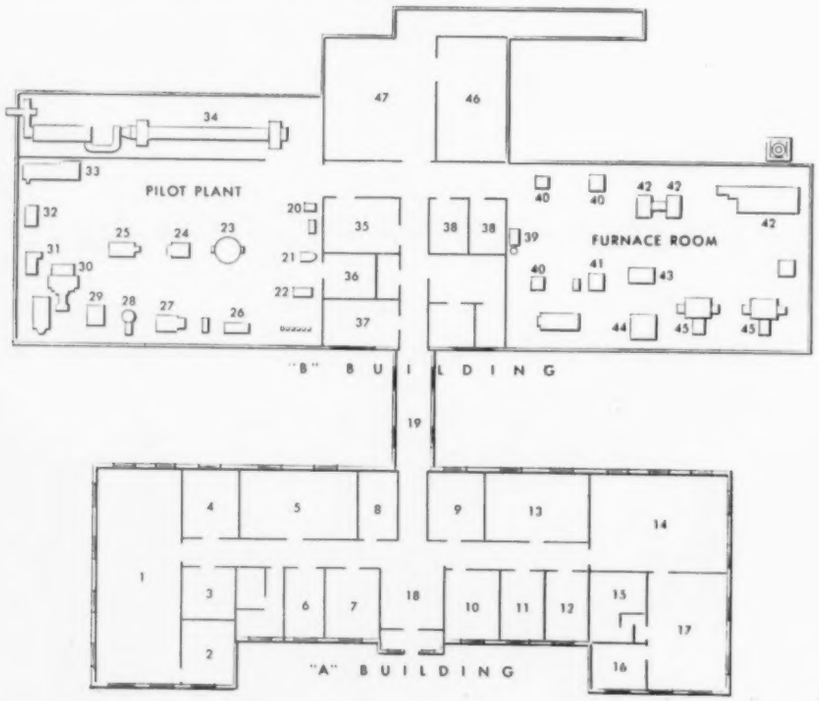
Another room houses a spectrograph, which can detect the presence and estimate the amount of almost any element that might be present in a refractory sample. This unit requires only a tiny sample, and can give the result within a few minutes, showing minute quantities of an impurity that might not be detected by ordinary chemical analysis.

Since the properties of a refractory are not a matter of chemical content alone, but depend also on how the elements are combined, further investigation is carried on by X-ray spectrograph with a Geiger counter that surveys the spectrum while an automatic record is made. Here the constituents of the material are identified through diffraction of the rays by the atoms of the material. Every crystalline substance produces a characteristic X-ray pattern which can be matched against standard records for the substances most commonly encountered in industrial research.

Although able to spot even the smallest crystals, X-rays, however, cannot detect a glassy constituent. Hence, the petrographic microscope, using polarized light, is called upon. With this equipment, isotropic material, such as glass, can be differentiated from most of the crystalline constituents, and quantitative measurements of optical properties that identify the different substances present can be made. To study texture of a refractory, slices of the material can be ground and polished to such thin sections that most of the constituents become transparent, or the piece may be handled by metallographic methods wherein it is ground flat and polished, and finally examined under a metallographic microscope by reflected light.

The petrographic microscope is also used in obtaining basic information regarding the many compounds and crystalline solutions that can be formed from various combinations of the components normally found in refractories and in slags that the refractories must withstand in various processes. High frequency

Figure 1 — Plant of the General Refractories Co. Baltimore laboratories. (1) Analytical chemical laboratory. (2) Balances. (3) Chemical storage. (4) Office. (5) Pyrometer calibration. (6) Drafting — supplies. (7) Library. (8) Record storage. (9) Office. (11) Photography. (12) Thermal expansion. (13) Conference. (14) Petrography and phase equilibrium. (15) Dark room. (16) X-ray. (17) Spectrograph. (18) Lobby. (19) Ramp. (20) Jaw crusher. (21 Screens 18 in. x 18 in. (22) Ball mill. (23) Dry pan. (24) Triple deck screens — 2 ft x 5 ft. (25) Ball mill — air swept. (26) Paddle mixer. (27) Wet pan (28) Muller mixing pan. (29) Extrusion unit. (30) Hydraulic press — 450-ton. (31) Hydraulic press — 200-ton. (32) Dryer. (33) Stiff mud brick machine. (34) Rotary kiln. (35) Testing — mortars and plastics. (36) Instrument storage. (37) Sampling for chemical laboratory. (38) Offices. (39) P.C.E. furnace. (40) Electric furnaces. (41) Carbon disintegration. (42) Panel spalling test. (43) Load test. (44) Hot modulus of rupture. (45) Reheat kilns. (46) Compressive, transverse strength and hardness testing. (47) Receiving and storage.



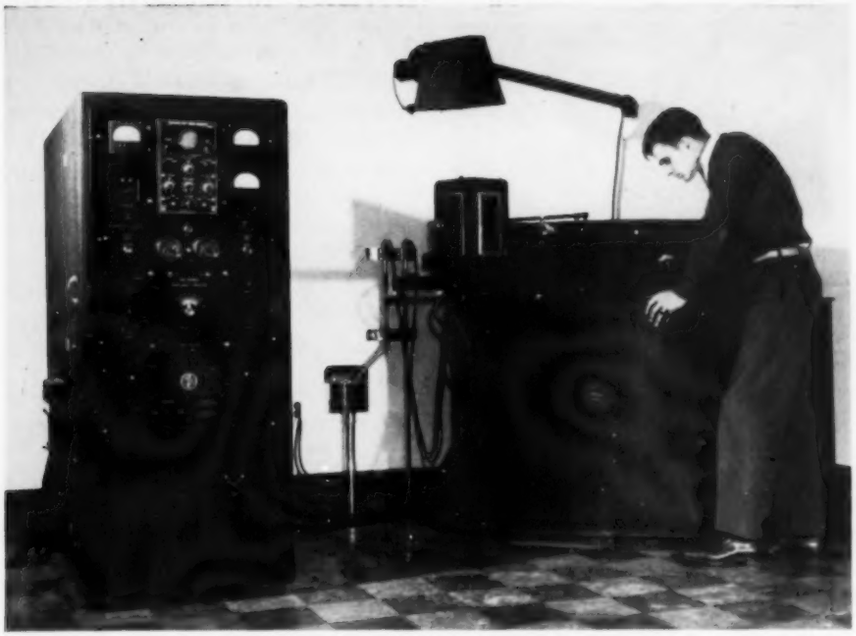


Figure 2 — Equipment for analyzing samples by spectrographic methods.

furnaces, fed from a 4 kva quenched-gap high frequency converter, are used to heat the materials to be studied. The contents of these furnaces can be subjected to high vacuum or to protective atmospheres, as desired.

For determination of thermal expansion properties, two types of equipment are provided. A dilatometer can measure accurately the expansion of individual constituents of a refractory, using the phenomenon of interference of light waves to measure the change in height of a specimen. Other apparatus, using two telescopes, is used to measure the expansion of a whole brick.

Almost one-half of the second unit (building B) of the laboratories is taken up by a furnace room containing equipment for testing refractories. Spalling properties are determined by a unit wherein an actual patch of refractory wall is alternately heated and then chilled by a blast of mist-carrying air. The average loss of weight of the bricks after a specified number of cycles is an index of spalling proclivities.

Two oil-fired furnaces and two electric resistance furnaces offer facilities for reheat tests to determine permanent shrinkage or expansion of a refractory. One of the latter furnaces can be operated with controlled atmosphere.

For determining the strength of refractories, a complete set-up of testing machines for crushing, transverse breaking and tensile strength is installed. A special item is the machine for measuring bending strength and modulus of electricity under elevated temperature. In another unit, six separate brick may be subjected to independent loads of 25 psi and heated according to prescribed schedule for 1½ hr, then allowed to cool, still under load. The amount and character of the resulting deformation is then measured.

Other equipment includes a special furnace for testing the susceptibility of refractories to carbon monoxide (particularly important in brick for blast furnace linings), a vertical cylindrical furnace fired with acetylene and oxygen for pyrometric cone equivalent tests, and a high frequency induction furnace (powered from a 40 kva converter) for large scale tests on the behavior of refractories and slags.

Facilities are also provided for testing mortars and cements, including the water-retention test, consistency and workability tests, and a settling test, which was developed by this laboratory.

Perhaps the most unusual feature of the new laboratories is the full scale pilot plant, which occupies half of the second (B) building and contains nearly a score of machines that permit the manufacture of almost any refractory product in lots ranging from a few hundred pounds to several tons.

Crushing and grinding may be performed in a jaw crusher, a dry pan, a pulverizer, a batch ball mill for wet grinding, and an air-swept continuous ball mill for dry grinding. Screening and sizing may be conducted in a triple-deck, inclined vibrating screen

Figure 3 — X-ray spectrograph for studying the crystalline structure of refractories.

Figure 4 — View of one section of furnace room, showing reheat furnace at left, load test furnace in center, and furnace for testing effects of carbon monoxide at right.

Figure 5 — General view of pilot plant, which is equipped for duplication of all manufacturing plant operations.

or in an agitating machine in which the screens are stacked vertically.

Brick or plastic mixes can be mixed and tempered in a wet pan or in a rubber-lined mixer, while mortars and castable refractories can be batched in a vertical mixer with squirrel-cage beaters or in a steam-jacketed mixer with helical revolving blades.

A small, slow-acting 200-ton hydraulic press and a large, quick-acting 450-ton press are available for forming by the dry press method, while forming by extrusion may be accomplished in either of two machines, one equipped with a 2-in. square die and the other with a die large enough to form standard 9-in. straights.

Drying can be studied in a specially designed 100-brick dryer in which air velocity, temperature and humidity can be controlled. Provision for calcining or dead-burning has been made in the form of a 30 ft x 3 ft, oil-fired rotary kiln. The speed and angle of descent in this unit can be varied. Commercial burning is carried out in the previously mentioned reheat furnaces in the furnace room of the laboratories or in plant kilns.

The installation of this full scale pilot plant makes possible the production of sample batches of refractories without interference with regular plant production schedules. The choice of equipment will also permit fundamental research on dry pressing and rotary kiln firing, two lines of development in refractories that have progressed almost wholly by experiment and mechanical invention.

Figure 6 — High speed, 450-ton hydraulic press for forming brick shapes under high pressure.

Timken Roller Bearing Co.

CELEBRATES 50 YEARS OF PROGRESS

▲ Timken Roller Bearing Co. celebrated its fiftieth anniversary with its first full scale open house for the public during the week of June 20th. The company is spending approximately $50,000 to tell visitors how it has grown in fifty years from a small carriage factory to the world's largest producer of roller bearings. The company was formed in 1899 and is a venture dedicated to the elimination of friction wherever wheels and shafts turn. One of the things of which the open house visitor was reminded was how important a factor taxes are in the operation of the concern. The company spends $58,179 a day in taxes. It is money, which the company stresses, could be used better for the purchase of newer and modern equipment, and for capital expansion.

It was not founded with the purpose of becoming a large organization, but rather as an expression of its founders' keen interest in the idea that the full potential of the wheel would not be realized until the friction and wear under which it labored were materially reduced by an anti-friction device. To reach this goal the company has spent millions of dollars for the necessary research and development of hundreds of types and sizes of tapered roller bearings and many of the machines on which they are made.

In the fifty years since the first Timken tapered roller bearing was

built and installed on a carriage axle some five billion bearings, ranging in weight from two ounces to 9,068 lb, have been made for use in automobiles, railway locomotives and cars, steel mills, airplanes, ships and all types of industrial machinery.

In the 1880's, Henry Timken, then a carriage builder in St. Louis, Mo., figured that anyone who could make wheels turn with greater smoothness, ease and quietness would contribute a great deal to the progress of the world which, at that time, already was stretching the capabilities of the wheel to the limit.

Experiments with the ball bearings then in use in bicycle wheels proved them inadequate for rugged service in carriage and wagon wheels and he was constantly seeking a solution to the problem. It was on his first return to St. Louis after retiring from active business and moving to California that he finally worked out the first drawing of the tapered roller bearing while lying on a sick bed and fretting because of his enforced idleness.

He gave the drawing to William Timken and returned to San Diego, leaving his two sons to make a set of roller bearings by hand. Young Henry and William set to the task with determination. When they had finally assembled a complete bearing-equipped axle on a wagon they filled it to overflowing and bought two small mules to pull the load to the railroad station four miles away.

In less than an hour William was called to the telephone. The call was from his driver, who said that he had been arrested and charged with cruelty to animals. William went to the police court immediately, showed the magistrate one of the new roller bearings and convinced him that the mules could actually handle the big wagon because it was equipped with the new bearings. The case was dismissed and the publicity which it aroused was the first public notice of the new anti-friction device.

Upon hearing of the story, the elder Henry Timken returned to St. Louis from San Diego.

Several more years of experimenting with the roller bearing convinced them beyond doubt that they were on the right track and the elder Timken patented the bearing in 1898.

Feeling that he was no longer capable of the tireless experimenting on the new bearing, he turned all active work on the project over to young Henry and William in 1899.

They continued their work in their father's factory but formed a new company, The Timken Roller Bearing Axle Co. The two boys used a 20 by 35 ft section of the shipping department of the Timken Carriage Works as their first assembly room. Manufacturing of the various parts of the bearing and axle had been farmed out to various firms and about a half a dozen men were hired to assemble the axles and bearings into a complete unit.

The demand for the new tapered roller bearing-equipped axle became so large that the boys decided to build a plant to manufacture the bearings. They soon found themselves beset with delays in getting material, high freight charges and other inconveniences, and decided to move. Careful consideration of all factors finally led the Timken brothers to settle on the city of Canton.

The axle business was reorganized in 1909 as The Timken-Detroit Axle Co. and incorporated as a separate company. The bearing section was incorporated at the same time as The Timken Roller Bearing Co.

With the axle-making end of the business gone from Canton, Henry and William were able to turn their full attention to the roller bearing.

Although the company had been growing continuously since it was founded, the period from 1909 to the beginning of World War I saw the thriving business expand both in the number of bearings made and the number of applications on which they were used. The original business was all in the carriage, wagon and automotive fields and the bearings were doing a wonderful job on these applications. "Could the tapered roller bearing do for other types of machinery what it had already done for mobile equipment?" was the question in the minds of Henry and William. They thought it could and decided to try as their next target the industrial machinery field.

Many discouraging incidents followed this decision but with continued experiments on different types of bearings and methods of mounting them with Timken bearings gradually were accepted by more and more enterprising builders of mine cars, machine tools, farm tractors and implements. Here was an entirely new field for the company's product. A field which would enable it to aid further in the progress of the oncoming machine age.

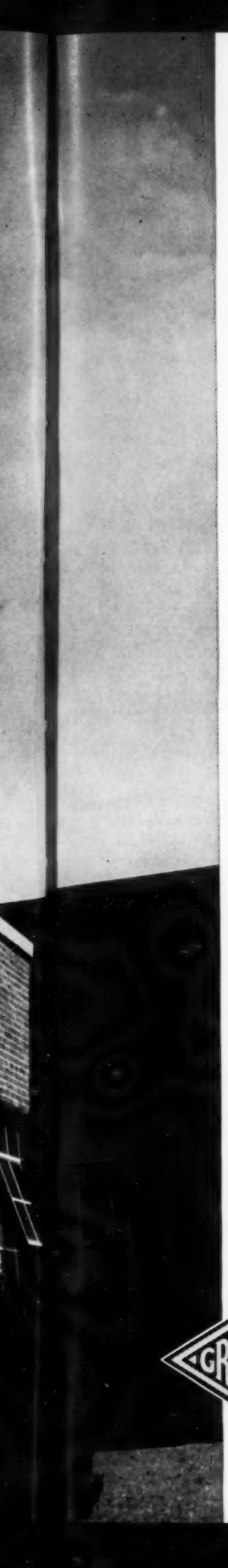
Other new applications were developed in the next several years and when World War I was being fought the industrial bearing business expanded to such proportions that by 1918 the company had salesmen in the field devoted to this one phase of operations and the Industrial Division was organized in 1919. Since that time Timken bearings have been applied to every kind of machinery where rolling friction is a problem. The combined output of bearings for both the automotive and industrial

(*Please turn to page 88*)

Figure 1 — Seamless steel tube is a Timken Steel and Tube Division specialty.

Figure 2 — The spectrograph is used for direct-reading steel analysis, and analyses are obtained and sent back to the melt shop in a matter of 5-6 minutes through pneumatic tubes.

GENERAL REFRACTORIES COMPANY
LABORATORIES



a new **Grefco** research and control laboratory

BUILT TO HELP YOU AND YOUR INDUSTRY— and to help Grefco make and sell even better refractories

For the past 23 years much of the progress in refractory development and refractory use has come out of Grefco's Baltimore Laboratory. Naturally we're proud of this and want to continue our leadership. Being aware that tomorrow's industrial processing will challenge refractories more than ever before, we have built and equipped the most modern laboratory in the industry.

Here physical and chemical research are conducted continuously, using the latest of scientific equipment —much of it never before applied to this field. This constant research holds many benefits for the users of refractories. One of these is lowered production costs through longer furnace life. And these benefits are yours whether we assist you with a specific problem or regularly supply you with improved Grefco products.

GENERAL REFRACTORIES COMPANY

PHILADELPHIA 2, PENNSYLVANIA

GREFCO *A Complete Refractories Service*

(*Continued from page 85*)

markets soon posed varied production problems.

One of the chief of these was obtaining uniform quality of bearings. The company found that the quality of workmanship and precision could be maintained at consistently high levels but the quality of alloy steel, which it was purchasing from various steel firms, was a variable over which it had no control.

Even with trained Timken inspectors checking the steel being made in the suppliers' mills to make sure it was melted and worked to company specifications, the supply did not match the quality desired.

It was this insistent demand for quality that in 1915 prompted the company to build a steel mill to produce the alloy steels needed to maintain a consistently high-grade product rolling from their bearing production lines.

That fall the company was in the production of seamless tubes made from purchased steel rounds. The tubing was cold drawn, annealed, straightened and cropped, ready for fashioning into cups and cones in the bearing factory.

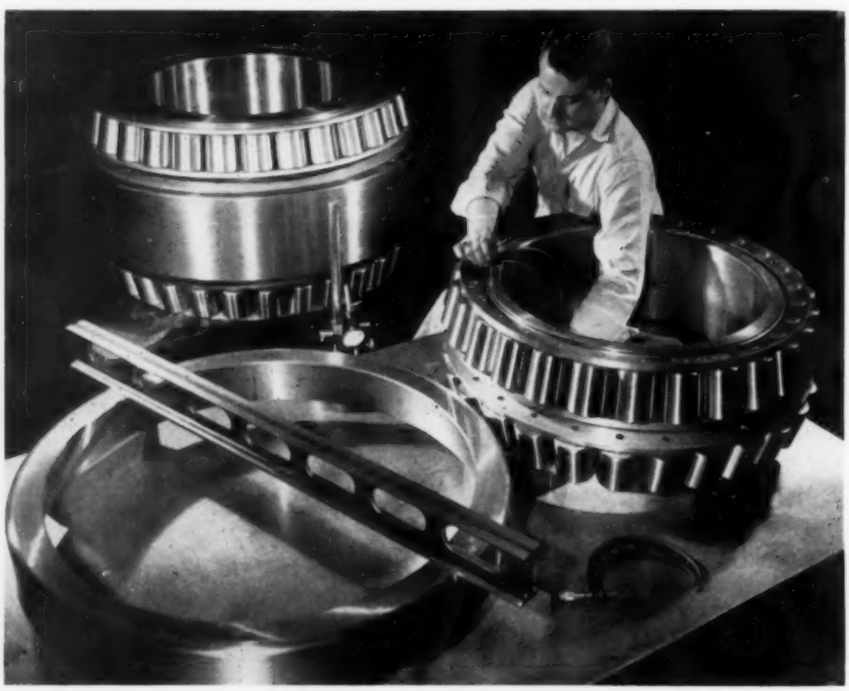
Results of this installation also proved so successful that the following August three five-ton Heroult basic electric furnaces were installed in the mill. At the same time, soaking pits for reheating ingots, a 500-ton press for forging ingots into blooms and a 22-in. mill for rolling blooms to rounds for piercing were placed in operation.

In a little over a year a company which refused to compromise on quality was making its own high-grade alloy steels and little dreaming at the time that eventually it would become the producer of the finest alloy steel to be made anywhere.

Year after year since the mill was started, the steel-making facilities of the company have been expanded and improved until they now cover 867,000 sq ft on a mile-long stretch on Harrison Ave. and have overflowed to Gambrinus, southwest of Canton, where equipment is installed in buildings covering 642,000 sq ft and the mill at Wooster, Ohio, covering 125,000 sq ft.

By the latter part of 1925, it had been demonstrated to the officials of the company that high-grade electric-furnace steels could be fabricated and sold at a reasonable profit. It was also apparent that the cost of operating reduced by the addition of more tonnage. Equally apparent were the economies which could be obtained from a modern melt shop as compared with the hand-charged battery of five obsolete Heroult electric furnaces then in use.

Figure 3 — This final inspection of a large mill bearing is only one of the many inspections required to produce a quality bearing.



A study of these facts led to a recommendation on April 24, 1926, that a new melt shop be built which would consist of a seven-ton Heroult electric furnace, two 15-ton Heroult electric furnaces and a 100-ton basic open hearth furnace.

This recommendation was approved and the above furnaces were installed, together with modern mechanical charging equipment. In March, 1927, steel was tapped from the new furnaces, which were located in the present melt shop. It was soon apparent that the vision and planning of the Timken management was sound because steel produced in the new melt shop cost about one-third less than that produced in the original steel plant.

During 1926, many studies were also made with the idea of modernizing the existing rolling mills. As a result of the various management studies made in 1926 and 1927, the following construction was authorized and built during 1928 and 1929. Two 100-ton open hearth furnaces were added to the melt shop. One 100-ton Heroult electric furnace was built. This was and still is the largest electric furnace in the world. In addition, a scrap storage building at Gambrinus, soaking pits, a new 22-in. mill, a new 10-12 in. mill, a new substation on Harrison Ave., the steel mill office building on Harrison Ave., which housed operating, chemical and metallurgical units, a new roll shop, and a new shipping building were erected. Additional machine-shop capacity, new annealing furnaces, and other processing machines were added.

With the addition of this new equipment, Timken bearings were used throughout the entire steel plant either on tried or untried applications. This was the forerunner of the extensive steel mill bearing business which the company enjoys today.

Additional land for expansion was purchased at Gambrinus, and a finishing plant with a capacity of 1500 tons was put into operation at that location in May, 1929. Estimates were also made on the erection of a new piercing mill at Gambrinus. This unit was constructed in 1929 and put into operation January 26, 1930. Although many other additions of equipment were made to the division, the main buildings erected in the late 1920's and early 1930's shaped the steel division as it exists today.

More recent additions include the enlarging of the original furnaces. No. 1 electric furnace was increased to 25 tons capacity; No. 2 and No. 3 electric furnaces were each increased to 40 tons capacity; the three open hearths were enlarged to capacities of 120 tons each; No. 8 electric furnace with 70 tons capacity was built in April, 1938; and in April, 1941, No. 9 electric furnace with 85 tons capacity was added.

In the last 10 years, a number of hood annealing furnaces were built at Gambrinus. During this same period, most of the rotorolling machines were eventually moved to the Wooster plant. In May, 1941, a rotary hearth furnace was built at Wooster for the piercing mill, and this unit was so satisfactory that a second rotary hearth furnace was built at the Gambrinus plant in April, 1943.

These units were a marked improvement in the uniformity and time of heating required in handling billets for the respective piercing mills. On July 1, 1941, a tool steel mill was installed at Gambrinus for rolling tool and specialty steels in rounds, flats, hexagons and special shapes. On July 19, 1943, a 1000-ton hydraulic press was installed at Gambrinus to facilitate the production of 16-25-6 alloy, which was being required in substantial quantities for aircraft superchargers. On May 1, 1945, a 3000-ton press was installed at Gambrinus to increase the range of sizes which could be furnished in 16-25-6 and other specialty steels.

The steel and tube division has a present-day capacity of approximately 50,000 ingot tons of electric furnace and open hearth steel a month. This is about five per cent of the total alloy steel capacity of 1,000,000 tons per month for all producers. Regardless of this relatively small capacity, Timken is undoubtedly the largest of the specialty steel producers.

The three seamless tube mills makes it the largest producer of alloy seamless mechanical tubing in the world, and within its range of production, heavier wall thicknesses can be produced than are obtainable from practically any other fabricator.

The fact that all operations from melting through rolling and fabrication into the final product are accomplished in one plant gives a quality control that is often not possible in larger non-integrated mills. More than 200 different analyses are produced.

COAL UNLOADER HAS UNUSUAL REEVING ARRANGEMENT

By J. W. DEIST
Dravo Corp.
Pittsburgh, Pa.

General view of the Pittsburgh & Lake Erie Railroad's river-rail trans-shipment station at Colona, Pa., on the Ohio River. Coal is brought by river barge to this station and transferred to railroad cars.

▲ Performance and maintenance records of a coal unloader operated at Colona, Pa., by the Pittsburgh & Lake Erie Railroad, show that numerous advantages have been realized over a period of several years because of a unique method employed for handling the bucket. This design features an unusual rope reeving arrangement that eliminates clutches and brakes on hoisting drums, minimizes spillage and simplifies the duties of the bucket operator. Moreover, the mechanical principles enable fast unloading of coal from barges. The load on the ropes which bring up the bucket of the unloader is equalized at all times, thus, no extra strain is placed on one rope.

The unloader consists mainly of a tower with built-in hopper, hopper gates and chutes, stationary horizontal cantilever boom carrying the rope-operated trolley, clamshell bucket, power machinery, and barge and car shifting equipment. The bucket operator's cab is mounted on the front column of the tower and allows full visibility of the barges, bucket and hopper.

The boom carrying the trolley extends out 112 ft from the tower over the river so the bucket can dig in either of two barges moored side by

(*Please turn to page 92*)

Let's look at the record!

Here are five cold strip mills where individual-generator drive systems—originated, engineered and equipped by General Electric—are on the job every day!

All of these mills are in actual operation, rolling thousands of tons of good steel per day. In every case the equipment for its individual-generator drive was engineered and supplied by General Electric. And in every case, it was so well engineered at the factory that it went into successful operation with minimum tune-up delay.

This improved type of steel mill drive was originated and first put to practical use by General Electric. By providing a separate generator for each drive motor, it offers these important advantages:

—**Cuts** equipment and maintenance costs by eliminating the need for high-current series boosters and by decreasing the number of circuit breakers required.

—**Lowers** bus installation costs and makes for a simpler, faster installation.

—**Maintains** proper speed relationship between stand motors at all times by built-in ohmic-drop compensation.

—**Reduces** tune-up time for actual production to as little as three days.

—**Assures** taking full advantage of the inherent speed regulation characteristics of specially designed d-c motors.

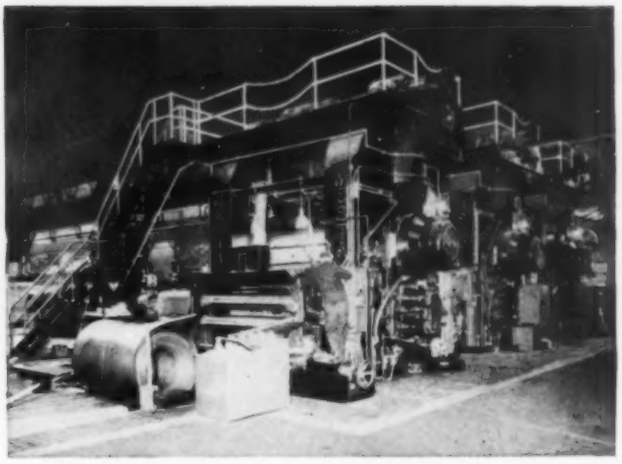
Successful installations like these emphasize once again General Electric's ability to handle your drive engineering problems. Why not talk them over with the G-E steel mill engineer in your area? *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

You can put your confidence in . . .

GENERAL ELECTRIC

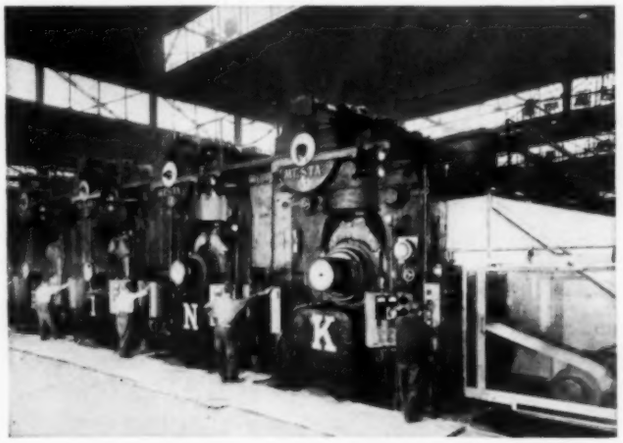
Courtesy Jones & Laughlin Steel Corp.

Fastest of its kind in the world is this 42-inch 5-stand tandem tinplate mill. Put into operation in October 1947, it rolls tinplate at a speed up to 6250 fpm—more than 70 miles an hour. And it rolls up to 851 tons of tinplate per turn!



Courtesy Great Lakes Steel Corp.

At a speed of 1600 fpm—faster than any other of its width—this 93-inch 3-stand sheet mill can top all others in tons per hour rolled. Installed in December 1947, its tune-up period took only 3 days.

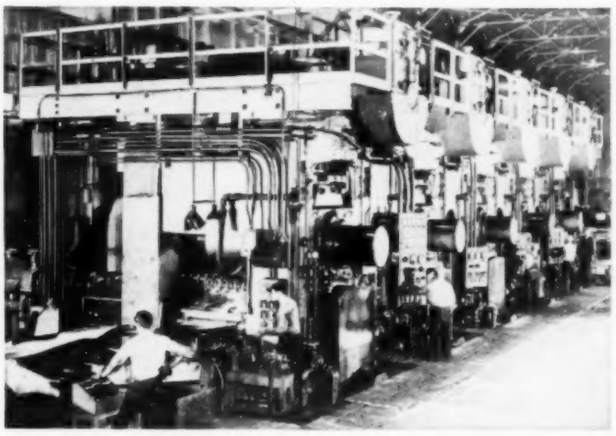


Courtesy Inland Steel Co.

This 42-inch 5-stand tandem tinplate mill began production in December 1948. Its rated delivery speed is 4330 fpm.

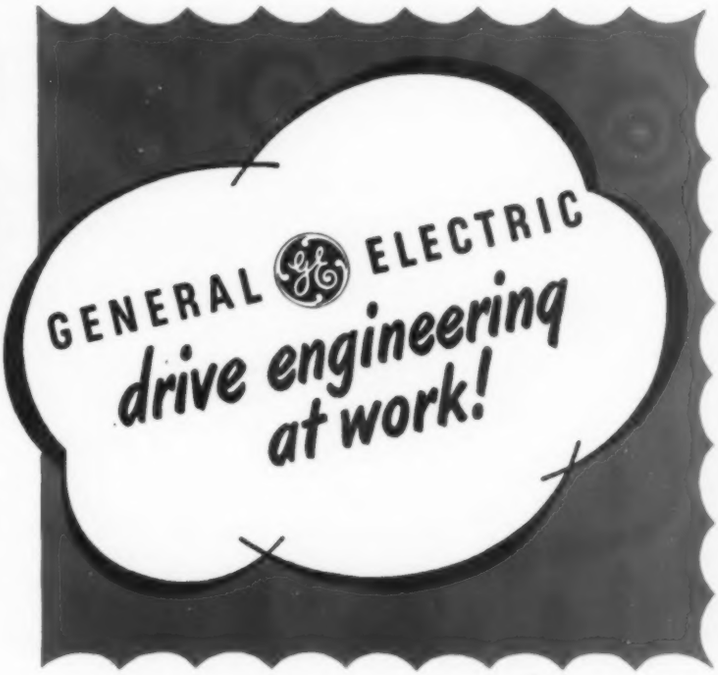
Courtesy Carnegie-Illinois Steel Corp.

Placed in operation in June 1948, this 54-inch 4-stand tandem sheet mill has a rated speed of 3300 fpm.



Courtesy Columbia Steel Corp.

First of its type in the West, this 56-inch 5-stand tandem cold strip mill went into production in July 1948. It rolls both sheet and tinplate at speeds up to 4100 fpm.



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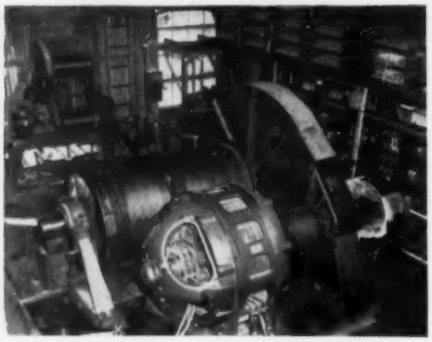

This is the hoisting mechanism located with the rest of the mechanical equipment for the unloader in a machinery house atop the steel structure. Attached to the drum are one end of the holding rope, one end of the closing rope and a counterweight rope. The counterweight is used to offset the weight of the bucket so that in hoisting, the electrical equipment lifts only the 7-ton load of coal.

side. The trolley boom extends out from the rear of the tower 23½ ft so the bucket can be lowered for servicing and changing ropes.

Electrical hoisting mechanism for the bucket consists of a single drum to which is attached one end of the holding rope, one end of the closing rope and a counterweight rope. In hoisting, the counterweight balances out the dead weight of the bucket so the electrical mechanism lifts only the 7-ton load of coal. The hoisting drum is driven by herringbone gear reduction from a 350-hp, 440-v, 3-phase, 60-cycle, a-c wound rotor motor. The pinion shaft is connected to the motor by flexible coupling and an electric-operated brake is fitted to the extended pinion shaft.

The closing mechanism is virtually of the same construction as the hoisting mechanism except only the closing rope is attached to the drum and is driven by a 150-hp motor.

This design is distinguished from conventional types of equipment for handling clamshell buckets by the fact that both the holding and closing ropes are attached to the same drum and a separate closing hoist is used.

Rope reeving in this design is as follows: The 1-in. steel wire holding rope, attached to the hoisting drum, is led over a sheave at the rear end of the trolley runway along the runway to the bucket trolley, over a sheave in the trolley to the bucket, back to the trolley and then to the front end of the runway where it is anchored to an equalizer beam. This rope is 466 ft long. The 1-in. closing rope, also attached to the hoisting drum, is reeved in the same manner, except that in the return from the trolley it runs over a sheave on the equalizer beam and back to the closing drum in the machinery house. The closing rope is 667 ft long.

To reduce rope-changing time and simplify the work, a winch is provided for rereeving. The winch is wound with small diameter steel wire that is fitted on one end with a basket weave sleeve to seize the end of the larger rope. As the existing rope is pulled out of the system, it threads the small diameter wire through the sheaves. After attaching the new rope to the small rope, it can then be pulled back through all the sheaves by the rereeving winch quickly and easily.

The equalizer beam is spring-mounted with fixed stops that provide limited motion. In hoisting, it is free of the stops and permits equalization of the load on both the holding and closing ropes. When the bucket is digging coal and being closed, the equalizer acts to permit all the load to fall on the closing rope.

The closing drum performs the double duty of opening and shutting the bucket. When the bucket is to be opened, a sufficient amount of the closing rope is paid out to permit the jaws to spread. The bucket is closed by taking up the same amount of rope that was paid out in opening. Limit switches stop the motor and set brakes in both the closing and opening operations, automatically taking up or paying out the correct amount of rope.

In the operator's cab there are three control levers for the unloading operation. One is for the closing hoist motor, one the hoisting drum motor and the third the trolley motor.

With the big bucket resting on the coal pile in the barge, the operator moves the closing motor controller to close position. This starts the closing rope drum which takes up enough rope to close the bucket. Current is broken and brake applied automatically by the limit switch. Next, the hoist control lever is moved to energize the hoisting drum motor. If the bucket has not fully closed when power is applied to hoisting drum, closing is automatically completed by the pull on the closing rope from the hoisting drum. As soon as the bucket is closed the load is equally distributed on all ropes and the bucket is hoisted. To open the bucket, the operator merely pays out the closing line.

The unloader was intended to complete one hoisting cycle in about 30 seconds. However, in actual operation a complete hoisting cycle is completed in 28 seconds. An average of 5500 tons is unloaded per day on two shifts.

There is a demand for copies of the following Yearly Proceedings:

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Wellman 13¼ net ton ore bridge, fitted with 192 cubic foot Wellman Williams type ore bucket.

• This new installation, built for one of America's largest steel companies, embodies many engineering features which speed the handling of ore and curtail costs.

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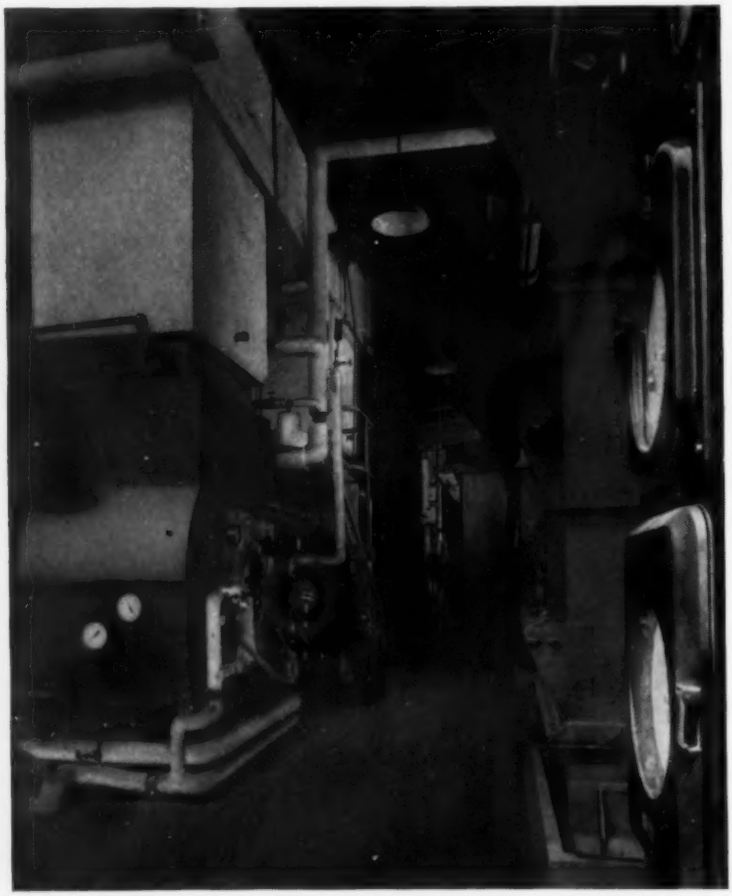
Three-fuel boilers, with HAGAN at ALAN WOOD STEEL COMPANY

The two new boilers in the Blast Furnace division of the Alan Wood Steel Company, Conshohocken, Pa., were designed to use blast furnace gas when it is available, coke oven gas when there is an unsold surplus, and Bunker C fuel oil when necessary.



General view of boilers. H. M. Wilson Co., Philadelphia engineering and construction firm were consulting engineers on this installation.

Each boiler has a capacity of 150,000 lb./hr. They are presently operating at 165 p.s.i., but are designed for operation at 700 p.s.i. to meet future requirements.

Heat content of the blast furnace gas is approximately 90 B.t.u.'s per cubic foot; of the coke oven gas, 540 B.t.u.'s per cubic foot; and of the fuel oil 150,000 B.t.u.'s per gallon. Blast furnace gas pressure varies from 5″ to 25″.

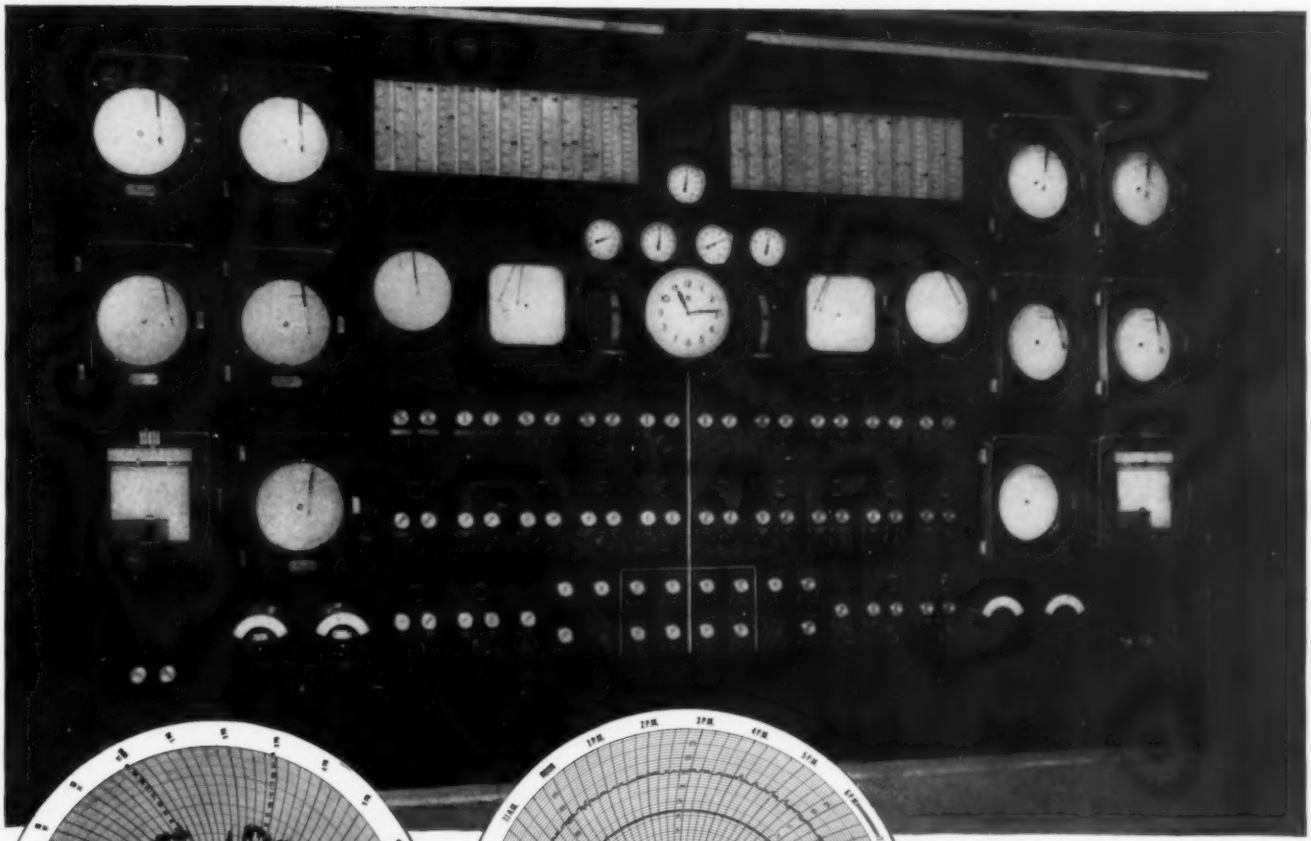
In spite of these variables, and of wide swings in steam load, the proper air-fuel ratio and the desired steam pressure are automatically maintained by the Hagan Differential Master system of combustion control.

Two fuel combinations are employed—blast furnace gas and oil, and coke oven gas and oil. Changes from gas to oil and oil to gas are automatic, but selection of the type of gas to be used is, in this installation, made manually. The charts reproduced at right show how the oil "takes over" to compensate for any deficiency in gas supply.

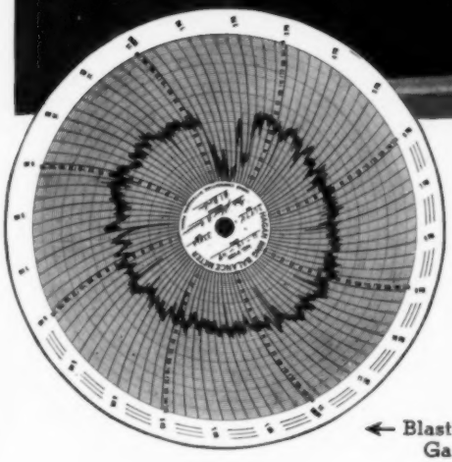
The Hagan Ring Balance Meters shown on the panel are used to measure and record gas flow, steam flow, and boiler water level. Two others, mounted on separate panels, measure flow of coke oven gas to the pilot burners.

For full information on Hagan Control and Hagan Ring Balance Meters, write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

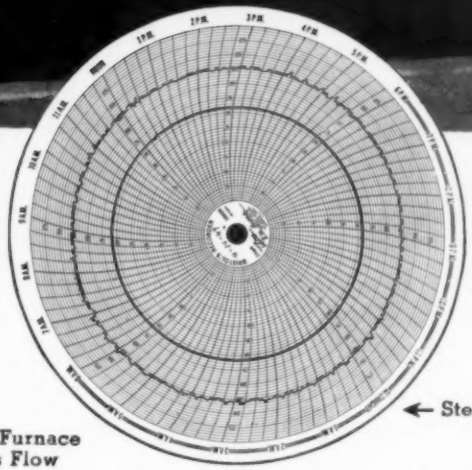
Controls and Meters



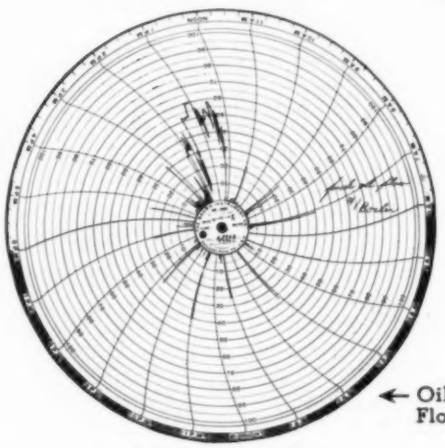
Control Panel of Hagan Differential Master installation at Alan Wood Steel Company. Ten Hagan Ring Balance Meters are mounted on the panel, two more are mounted on separate panels.



← Blast Furnace Gas Flow



← Steam Header Pressure (inner record)



← Oil Flow

Upper chart at left shows gas flow in one burner. "Valleys" in this chart are matched by peaks in the lower chart (oil flow). For the most part, it will be noticed, these "oil on" periods are of brief duration, but the charts show one period of several hours during which gas was off. The inner circle of the chart at the right shows how the Hagan Control maintained steam pressure under these conditions.

HAGAN CORPORATION

BOILER COMBUSTION CONTROL SYSTEMS
RING BALANCE FLOW AND PRESSURE INSTRUMENTS
METALLURGICAL FURNACE CONTROL SYSTEMS
THRUSTORQ FORCE MEASURING DEVICES

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MORE TONS PER PASS

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BILLET EJECTORS—PINCH ROLL STANDS
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TILTING TABLES—TRAVELING AND LIFTING TABLES
CONTINUOUS PICKLING LINES—ROLLER LEVELLERS
FURNACE CHARGING EQUIPMENT—FURNACE PUSHERS
STRIP STEEL COILERS AND REELS—SCRAP BALLERS
RAILROAD SPIKE FORMING MACHINES—ROLL LATHES
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The Youngstown Foundry & Machine Co.

Youngstown, Ohio

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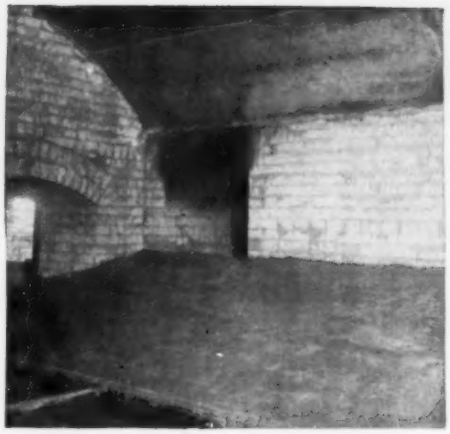
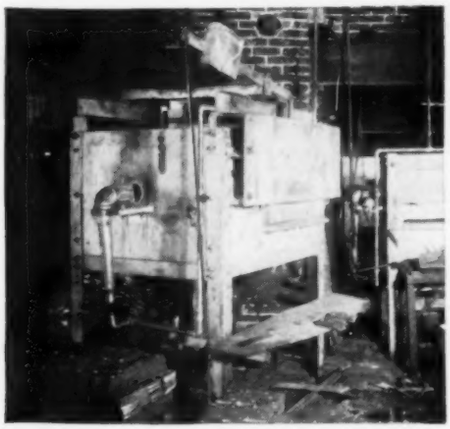
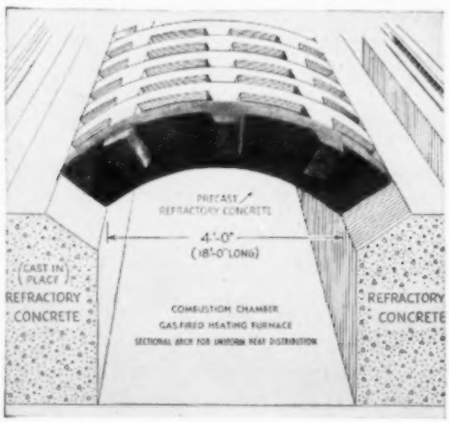


Incinerator Arch and Floor, quickly installed with Castables. No cutting, fitting, or ramming. Upkeep costs are low.



Heat-treating Furnace built with Castable Refractories. Cuts heat loss . . . prevents infiltration of outside air. Gives durable service life.



Combustion chamber of Gas-fired Heating Furnace. Each section of Arch is cast in one piece with Refractory Concrete. No mortar joints. Side walls and floor cast solid.

Practically any shape you want...

★ **FURNACE WALLS,**

★ **ARCHES, HEARTHS,**

★ **DOOR LININGS,**

★ **SPECIAL SHAPES**

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Quickly *adaptable* to any size, shape or thickness—Castable Refractories are invaluable first-aid for emergency repairs. Rapid hardening Castables are ready for service in 24 hours or less.

They're easy to use, too. Add water to the packaged mixture, cast it in a simple form or mold. Large jointless sections are as easy to cast as small special shapes. No cutting or fitting.

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Castables to meet different temperature and insulation requirements are made by manufacturers of refractories and sold by their distributors. For further information, write to LUMNITE DIVISION, Universal Atlas Cement Co. (United States Steel Corporation Subsidiary), Chrysler Building, New York 17, N. Y.

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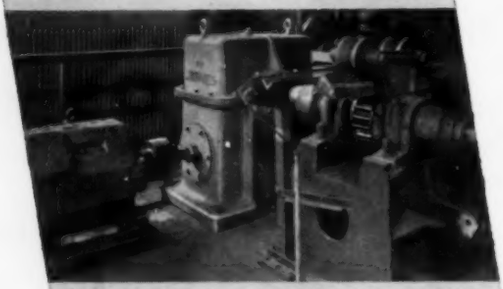
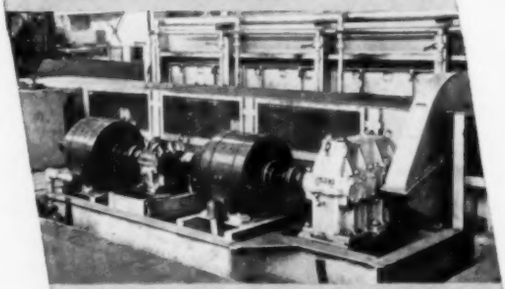
KEEP GOING

. . . WITH JONES

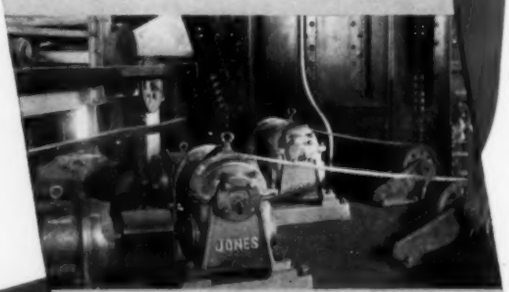
Jones Herringbone Speed Reducer driving steel tube mill draw bench. Gear casings removed to show proportions of spur gear drive to head shaft.



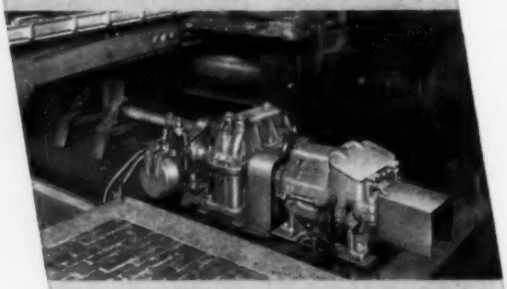
Jones Worm Gear Speed Reducer operating cover of warming pit in steel mill.



Jones Herringbone Reducers operating furnace in steel mill. Drive consists of two motors with single type and double type reducers coupled in series in order to obtain two widely varying speeds.



Two of a battery of 10 Jones Worm Gear Door Hoists for operating open hearth furnace doors.



Jones Herringbone Reducer operating sheet mill tilting drive on feeder table.

• In every phase of the steel business today, whether it is production or fabrication, the cry is "keep going".

The Jones organization, too, is busy manufacturing the various types of speed reducers and other transmission products that are so essential for drives in every type of plant — drives that are so necessary in maintaining peak production.

We picture here some typical Jones drives that have seen years of service in the steel industry. They have been called upon to take a lot of punishment and they will stand the gaff for a good many years to come.

W. A. JONES FOUNDRY & MACHINE COMPANY
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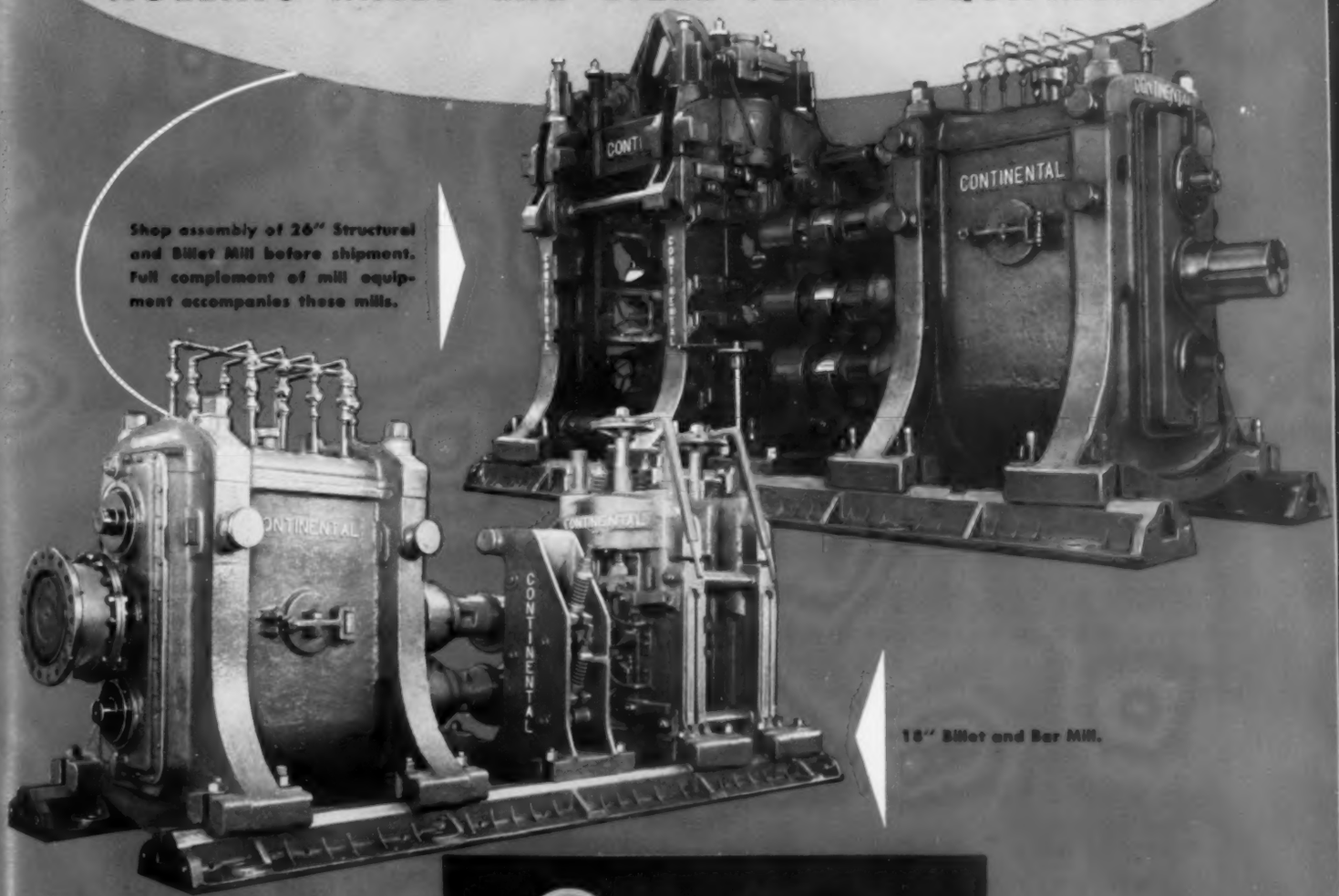
ROLLING MILLS and STEEL PLANT EQUIPMENT



Shop assembly of 26" Structural and Billet Mill before shipment. Full complement of mill equipment accompanies these mills.

18" Billet and Bar Mill.

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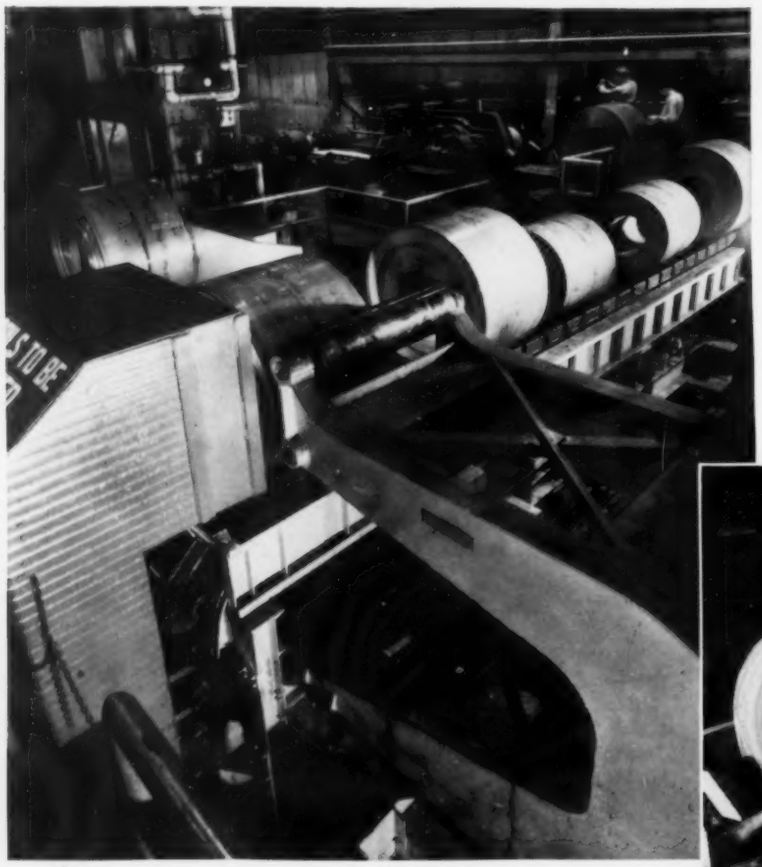
Iron and Steel Rolls
Carbon and Alloy Steel Castings

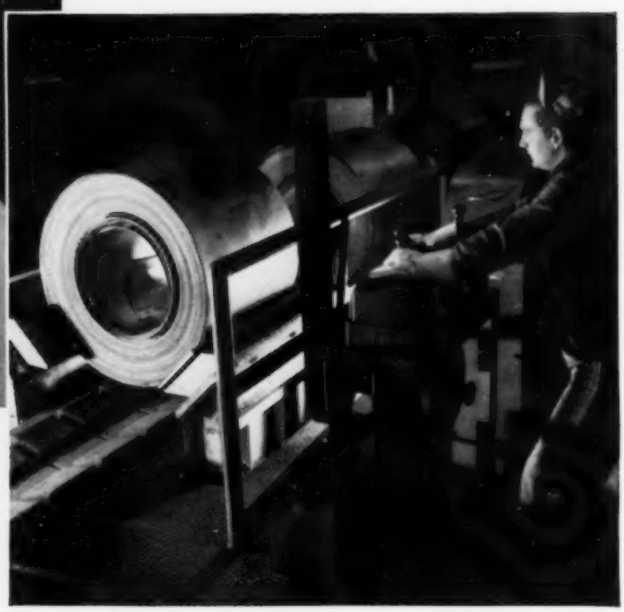
No Coil Edge Damage at Aliquippa

With LINK-BELT Coil Conveyors

Said to be the heaviest pallet type conveyors ever built for handling steel coils, the Link-Belt coil conveyors at the Aliquippa plant of Jones & Laughlin carry coils weighing up to 15 tons, on their sides.



At delivery end, coils are again weighed, then rolled onto conveyor and carried to hydraulic push-off in foreground, which transfers them to flat-top storage conveyor.



Link-Belt coil conveyor at weighing station, ahead of continuous pickling line.

Coils Ride on Side of New Type Conveyor

The bigger the coil, the greater the waste if edges are scuffed or coils telescope. The trend toward larger coils is matched by Link-Belt in developing the V-Top conveyor on which these heavy coils, resting on their sides, ride safely to and from the continuous pickling line.

Link-Belt coil conveyors protect while they transport. Ample bearing surfaces, rugged construction conforming to steel mill requirements, and advanced design, combine to provide safe handling at low operating costs.

A Link-Belt Engineer will be pleased to discuss your handling problems.

LINK-BELT COMPANY

Chicago 9, Pittsburgh 13, Cleveland 13, Detroit 4, Indianapolis 6, St. Louis 1, Kansas City 6, Mo., Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices in Principal Cities.

11,180

LINK-BELT
THE SYMBOL OF QUALITY
LB
LINK BELT
CONVEYORS
HANDLING EQUIPMENT . . . POWER TRANSMISSION MACHINERY

Cable pulled from conduit

AFTER 11 YEARS

. . . Reinstalled and back in use!

A major midwestern electric utility had occasion to relocate a conduit run in January, 1946.

This run had been wired with ROCKBESTOS A.V.C. cable in June, 1934. The installation was located in damper control circuits around the boiler, where the summer ambient is around 135°F.

When the wire was pulled out in order to relocate the conduit to accommodate equipment changes, the insulation was in excellent condition . . . *after more than 11 years of dependable service under severe conditions.*

After the conduit was relocated, the same ROCKBESTOS A.V.C. cables were pulled back in.

Order ROCKBESTOS A.V.C. by name. Install it. Then confidently forget it!

ROCKBESTOS PRODUCTS CORPORATION, NEW HAVEN 4, CONN.

NEW YORK CLEVELAND DETROIT CHICAGO
PITTSBURGH ST. LOUIS LOS ANGELES OAKLAND, CAL.

WIRES and CABLES *by*

ROCKBESTOS

. . . . dare to be better

Date-line Diary...

June 1

▲ Effective today, the General Electric Co. is restoring pre-war price policies.

▲ Based on reports from companies having 94 per cent of the capacity of the steel industry, the operating rate of the steel industry is scheduled to be 91.8 per cent of capacity for the week beginning May 31, 1949. This is equivalent to 1,692,300 tons of steel ingots and castings for the entire industry compared with 1,734,700 tons one week ago.

June 2

▲ According to the Engineering News-Record, total construction backlog showed a net increase of $1,300,000,000 during the first quarter of this year, and the backlog by the end of April was up to $44,600,000,000.

▲ On the London stock exchange, stocks dropped to their lowest levels since September, 1947.

▲ Charles E. Wilson, president of General Electric, predicted that industrial production may rebound to the high level of 1948 by the end of 1951. He estimated that industrial output is unlikely to drop more than 15 per cent from the 1948 peak.

June 3

▲ Phillip Murray, head of the CIO Steel Workers, said that he hoped there would not be a steel strike this year. However, he continued, the union will press their demands.

▲ Timken Roller Bearing shut down a 120-ton open hearth furnace, and alloy steel production in the Canton-Massillon area is at a ten year low.

▲ According to the Department of Commerce, construction work done in May was valued at $1,568,000,000. This is $200,000,000 over April, 1949, and fractionally less than May, 1948.

▲ General Motors Corp. set a new monthly output record producing 265,280 passenger cars and trucks during May in the United States and Canada.

June 4

▲ The Eastern Railroads applied to the ICC for permission to raise passenger fares 12½ per cent. Under the new rates, coach fares would be 3.375 cents a mile and first class rates would be 4.5 cents a mile.

June 6

▲ The Sharon Steel Corp. closed down its Lowellville, Ohio plant for at least two weeks.

▲ A bill, sponsored by Jos. C. O'Mahoney (Dem., Wyo.), which passed the Senate, will make legal, basing point and delivered pricing in the absence of collusion.

▲ Steel production in Britain set a new record in May with 1,367,416 tons. Pig iron production was 808,333 tons.

▲ Based on reports from companies having 94 per cent of steel capacity for the industry, the operating rate of the steel industry is scheduled to be 89.1 per cent of capacity for the week beginning June 6, 1949. This is equivalent to 1,642,600 tons of steel ingots and castings for the entire industry compared with 1,692,300 tons scheduled one week ago.

▲ Carnegie-Illinois Steel Corp. took No. 6 blast furnace at Duquesne off blast.

▲ Stock prices broke to a new two-year low and the Dow-Jones industrial average fell 2.09 points to 165.15. Volume was 1,380,000 shares.

June 7

▲ American Iron and Steel Institute announced today that the April payroll for the iron and steel industry was estimated at $191,886,000, a new record for the month. Earnings of hourly piece work and tonnage workers averaged $1.688 per hour and men averaged 38.5 hours per week.

▲ Republic Steel Corp. banked its No. 3 blast furnace at Cleveland leaving three out of five furnaces in operation.

June 8

▲ The Census Bureau reported that unemployment rose to a new post war high of 3,289,000 in May. Over-all employment for May was 58,694,000, or up 874,100 from April. Unemployment was also up 273,000 because of the large number of youths added to the labor market on completion of their schooling.

▲ American Railway Car Institute reported that domestic freight car deliveries in May totaled 9,525. New orders in the month totaled 589 and the total backlog is now 52,981.

▲ The E.C.A. authorized a continuous billet mill at Donawitz, Austria, and also a project for rehabilitating iron ore mining in the Erzberg field.

▲ In May, iron ore shipments in the Great Lakes set a new record with 11,655,668 gross tons of iron ore handled.

June 10

▲ Carnegie-Illinois Steel Corp. announced that it will close ten more open hearth furnaces and another blast furnace at the Duquesne Works. Six open hearths had been suspended last week.

▲ The Commerce Department stated that income payments to individuals had declined for the fourth straight month to an annual rate of $213,700,000,000.

▲ American Iron and Steel Institute reported that production in May was 7,683,428 tons of ingots and castings, the second highest tonnage ever made in this month.

June 11

▲ The Agriculture Department predicted a 1949 wheat crop of 1,336,976,000 bu for the second largest wheat harvest in history.

▲ The Census Bureau reported that business inventories on April 30th were $53,566,000,000 and down about $1,200,000,000 from the previous month.

June 12

▲ American Iron and Steel Institute reported that the amount of purchased scrap used in steel making furnaces in 1948 was 20,500,000 gross tons or greater than ever before. No. 1 heavy melting steel scrap was purchased at a market average of more than $40.00 a gross ton.

June 13

▲ Based on reports of companies having 94 per cent of steel capacity of the industry, the operating rate of the industry is scheduled to be 86.7 per cent of capacity for the week beginning

June 13. This is equivalent to 1,598,300 tons compared with 1,642,600 tons one week ago.

▲ The coal miners began a one week stabilizing walkout today. Since their vacation starts June 24th, the mines will be down three weeks.

June 14

▲ A Supreme Court upheld a government anti-trust suit against the Standard Oil Co. of California outlawing exclusive dealing contracts of the major oil companies.

▲ Stocks broke to the lowest level since the end of the war and the Dow-Jones industrial average slumped 3.01 points to 161.60.

▲ Refined copper price was reduced ½¢ to 16½¢ a lb.

▲ The Wheeling Steel Corp. reduced operations on one blast furnace, and four open hearths were taken out of operation at Steubenville.

June 15

▲ The House Banking Committee approved a bill which will extend for a year the authority of the government to allocate tin and tin products.

▲ The General Electric Co. rejected a proposal of the CIO United Electrical Workers for a pay increase of $500.00 per year per worker.

▲ The South Penn Oil Co. increased prices of Pennsylvania crude oil from 13¢ to 16¢ a bbl.

June 16

▲ Zinc prices were lowered ½¢ to 9¢ a lb.

▲ The Borg-Warner Corp. announced that it will stop operations on June 30th at its Superior Sheet Steel Division at Canton, Ohio.

June 17

▲ United States Steel Corp. rejected union demands for bargaining on pensions.

▲ John L. Lewis ordered his miners to go back to work on June 20th to put in a week's work before their annual ten day vacation.

▲ Crude oil production allotments in Texas were cut 125,101 bbl for the months of July and August giving a quota of 1,871,938 bbl daily. This is a cutback of 1,075,000 bbl from last December.

June 19

▲ The ECA will finance a new steel plant in France which will be owned by the Societe Lorraine de Laminage Continu. This company is a subsidiary of nine existing steel concerns. ECA will finance $49,360,000 of the $133,060,000 construction cost.

June 20

▲ Based on companies having 94 per cent of capacity of the industry, the operating rate of the steel industry is scheduled to be 84.4 per cent of capacity for the week beginning June 20, 1949. This is equivalent to 1,555,900 tons for the whole industry compared with 1,598,300 tons one week ago.

June 21

▲ The Bethlehem Steel Corp. closed down three open hearths at Buffalo. The Jones and Laughlin Steel Corp. closed down six 62-ton open hearths at the South Works.

▲ Republic Steel Corp. awarded the Koppers Co. a contract for the construction of a 65-oven battery of coke ovens at the Youngstown Plant.

▲ The Kaiser Co. announced that drilling tests have proved more than 30,000,000 tons of high grade coke and coal in Central Utah.

June 22

▲ Great Britain has purchased $151,200,000 more of foreign goods in May than what she sold abroad.

▲ The Phoenix-Apollo Steel Co. accepted the bid of M. E. Solomon of Pittsburgh for its steel plant at Apollo. Purchase price was not announced.

June 23

▲ The Economic Cooperation Administration announced that as an inducement for private U. S. investment abroad, the government will guarantee that foreign currency earnings in Marshall Plan Countries can be converted into dollars up to 175 per cent of the original investment.

June 24

▲ Scrap prices dropped in the Pittsburgh area to $21.00 a ton for No. 1 heavy melting scrap.

▲ The Carnegie-Illinois Steel Corp. shut down one of their blast furnaces at the Edgar Thomson Works.

June 25

▲ Government construction experts predicted that private business will spend $2,175,000,000 for trucks in 1949 and this will be 18 per cent below 1948. Overall construction is expected to be higher in 1949 because of increased outlays by public utilities and because of governmental construction.

▲ Automobile and truck output in the United States and Canada this week rose to a 20-year high of 150,948 units according to Ward's automotive reports.

June 26

▲ The F. W. Dodge Corp. reported that dollar valuation of contracts awarded this year east of the Rocky Mountains by public agencies was running 19 per cent higher than last year while private contracts were down 20 per cent.

June 27

▲ Based on reports of companies having 94 per cent capacity of the industry, the operating rate of the steel industry is scheduled to be 79.9 per cent of capacity for the week beginning June 27, 1949. This is equivalent to 1,473,000 tons of steel ingots and castings for the entire industry compared with 1,555,900 tons one week ago.

▲ American Institute of Steel Construction reports estimated total bookings of fabricated structural steel for May are 115,903 tons or 17.5 per cent over April. May shipments were 167,976 tons. The total backlog is about 600,000 tons.

June 28

▲ The Struthers Iron and Steel Co. is spending $500,000 to reline and rebuild its Struthers, Ohio blast furnace.

▲ Soft coal operators in the tri-state area rejected John L. Lewis's proposal for a three day week in the mines.

▲ The Pittsburgh Coke and Chemical Co. announced that it will furnish the General Motors Corp. with pig iron from its Struthers, Ohio furnace.

June 29

▲ With the closing of another blast furnace at Duquesne, the Carnegie-Illinois Steel Corp. is operating only two out of six blast furnaces and six out of twenty-seven open hearth furnaces at this location.

▲ A Republic Steel Corp. official estimated that second quarter sales are about 90 per cent of $215,000,000 volume in the first quarter.

June 30

▲ The National Tube Co. has announced that it will step up production on the No. 2 seamless pipe mill at McKeesport, from the present six-day week to a seven-day week.

▲ John L. Lewis ordered his soft coal miners to work for only three days a week starting July 5th.

▲ The Justice Department filed civil suit at Chicago charging that the E. I. du Pont de Nemours Corp., the General Motors Corp. and United States Rubber Co. with violations of the anti-trust laws. Mr. Greenewalt, president of the du Pont Co., denied the charges emphatically.

▲ Senate Finance Committee approved a bill which will cut Federal Excise taxes back to 1942 levels.

▲ Consumption of Lake Superior iron ore during May was 7,276,719 gross tons, of which 262,175 tons were used by Canadian furnaces.

Industry News...

INLAND STEEL COMPANY LAUNCHES LARGEST FRESH WATER ORE CARRIER

▲ Inland Steel Co.'s new ore carrier, the "Wilfred Sykes," largest ship ever built on fresh water, was launched at Lorain, Ohio, on June 28 from the yard of the American Ship Building Co., designer and builder of the ship.

In a ceremony attended by Inland and ship building company officials, and hundreds of other spectators, Mrs. Wilfred Sykes christened the new ore carrier, which until it was launched was known in the Lorain ship building yard as Hull No. 866. Her husband, in whose honor the ship has been named, is chairman of the executive committee and former president of Inland Steel Co.

It will be the largest ore carrier on the lakes—678 ft overall; will carry the most cargo—20,000 long tons at intermediate draft, 21,500 long tons at summer draft; will have the greatest speed—16.5 mpr loaded; will have the most powerful engines of any ore carrier—7,000 hp; and will weigh more than 15,000,000 lb without cargo, and more than 60,000,000 lb loaded.

The "Sykes" contains more than a mile of 12-in. diameter pipe through which water ballast will be pumped; has a cruiser stern, streamlined rudder and an 18 ft, 6 in. diameter propeller; will have 17 tons of anchors—two 6-ton anchors forward and a 5-ton stern anchor, and will have 2,160 ft of 2⅛-in. forged alloy steel chain; 540 ft of 1⅞-in. forged alloy steel chain.

Mooring lines will be wire rope 1⅛ in. in diameter. Hatch covers each weigh seven tons and are 11 ft by 44 ft. There are 19 hatches, with hatch covers being sealed with patent hatch clamps, lifted on and off by a gantry crane mounted on the spar deck.

CRUCIBLE CENTERS MELTING AT MIDLAND

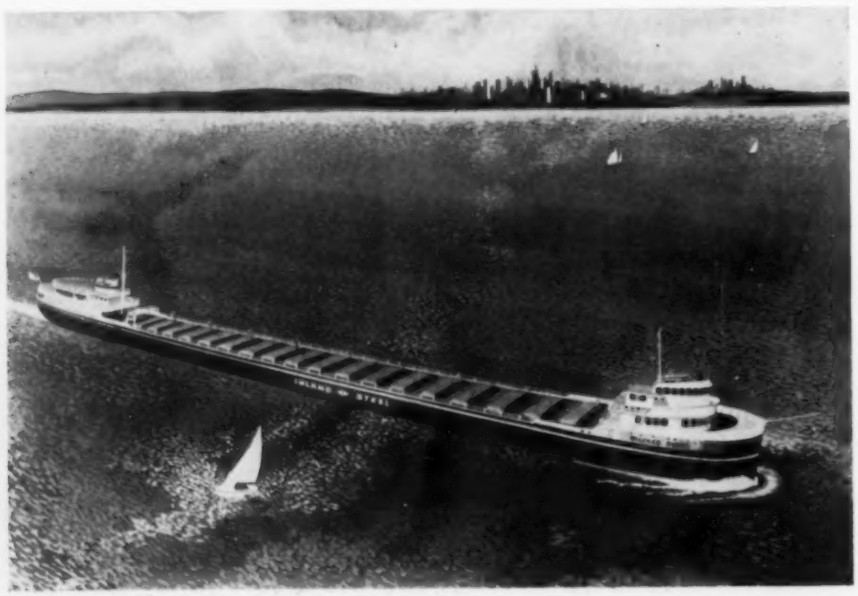
▲ In line with the plant improvement program of Crucible Steel Co. of America, the primary steel melting operations of Crucible have been centered in Midland works, Midland. Pa. Electric melting of steels continues in the Sanderson-Halcomb works, Syracuse, N. Y.

The modernization and enlargement of melting capacity at Midland works and Sanderson-Halcomb works have made it possible for Crucible to discontinue the small open hearth and electric arc melting operations in Park works, Pittsburgh, Pa. Park works electric induction furnace facilities are being kept in service.

Park works, which figured in a major way in the Crucible plant program, continues as one of the six production centers of the company. A modernized 9-in. bar mill has been installed to enlarge the Park works production of small bars and shapes. The plant continues as a leading producer of special bars and shapes for machinery, cutlery, tools and implements, and similar applications. The hollow drill and drill steel facilities have been greatly enlarged and improved, making Crucible one of the world's largest makers of drill steels for petroleum, mining, quarrying and allied industries. Park works finishing facilities for special polished stainless sheets have been expanded.

The Park works open hearth melting department was a World War I development, and comprised four basic open hearth furnaces, as well as two small electric arc melting furnaces. The Midland works and Sanderson-Halcomb works melting departments are now equipped to provide all grades of alloy, stainless and high-carbon steels manufactured by Crucible.

This 78 ft long ore carrier will carry 21,500 long tons of ore at summer draft.



EXPORT BUSINESS SHOWS MARKED CHANGE

▲ Numerous changes occurred in export markets for iron and steel from the United States in 1948, American Iron and Steel Institute announced.

The largest share of the exports went to countries in North and Central America and the West Indies. It was the first year since 1939 that these countries, as a group, had held first place. South American countries ranked second. Europe, for eight consecutive years the largest consumer of steel exports from the United States, dropped back to its prewar position of the third largest market.

Asiatic countries, which received

the largest percentage of iron and steel exports during 1935-39, were the fourth largest market last year. Africa continued to rank fifth. Australia and Oceania continued to take the smallest part of the exports.

According to final figures by the Department of Commerce, 4,697,405 tons of iron and steel were exported from the United States last year.

LORAIN WORKS WINS COUNCIL'S SAFETY AWARD

▲ The nation's highest safety award was presented to the 12,500 U. S. Steel employes at Lorain works of National Tube Co. for achieving one of the best safety records made recently in heavy industry.

The plant piled up an unbroken record of 2,164,841 manhours of work without a disabling accident.

In recognition of the feat, William A. Irvin, chairman of the board of trustees of the National Safety Council and former president of United States Steel, presented to the plant the council's top honor—the "Distinguished Service to Safety Award." The presentation took place at a dinner meeting of plant supervisors and safety captains on June 30.

The safety coordination of this plant of 12,500 employes is under the direction of a safety department which has a crew of safety inspectors and safety engineers, and a labor-management committee which operates in cooperation with an organization of approximately 275 mill safety captains.

ASH ENGINEERING MOVES TO PHILADELPHIA

▲ The Ash Engineering Co., which represents Hagan Corp. in the Philadelphia district, has moved its offices to 246 South 15th St., Philadelphia 2, Pa.

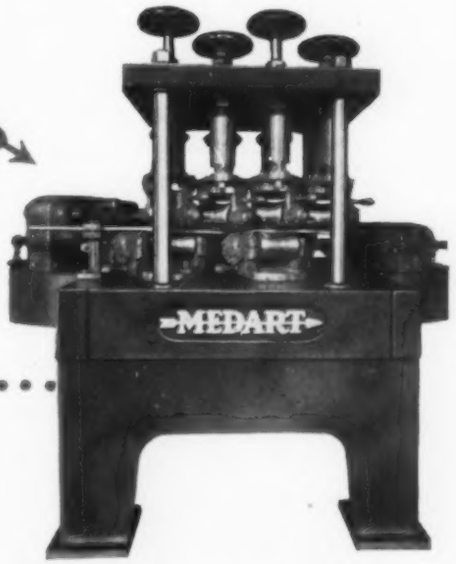
SELAS CORP. ACQUIRES DEHYDRATOR ACTIVITIES

▲ Effective July 1, 1949, the Selas Corp. of America, Philadelphia, Pa., will take over the industrial dehumidification equipment activities of equipment section, engineering division, Davison Chemical Corp., Baltimore, Md. R. S. Van Note, formerly manager of equipment section, has

MEDART MICRO-MULTICYCLE!

straightening machine designed exclusively for ⅛" to ½" bars and tubing.

Small, compact yet built on the same principle and embodying the same advantages as the Medart 6-in-1 Multicycle Straightener . . . positive, synchronized feed . . . one feeding level . . . two bending cycles . . . single motor . . . and the Medart Micro-multicycle has this PLUS FEATURE: all six rolls are driven! A variable feed-speed range is built into the machine. 3 H. P. motor mounted on base of machine.



MANUFACTURING ENGINEERS OF COMPLETE TRANSMISSION EQUIPMENT AND SPECIALIZED MACHINERY

MEDART

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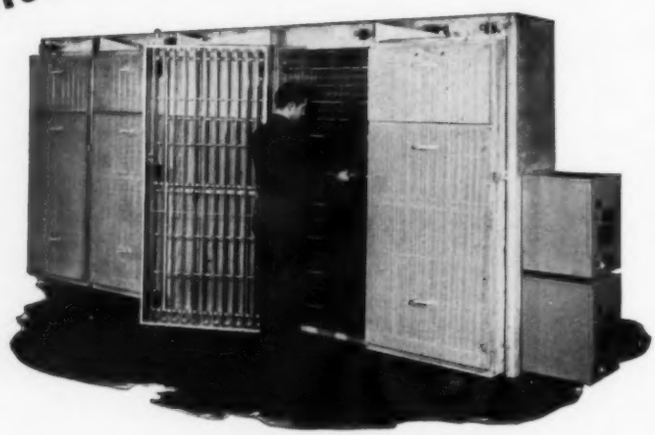
Where clean air returns a cool profit



COOLING mill motors—either by force ventilation or a recirculating system—introduces a serious air cleaning problem. All of the air used with forced ventilation or that portion required for make-up with recirculation must be cleaned. The nature and volume of dust created by steel mill operation makes it necessary to clean any outside air entering the motor room.

This emphasis on clean air has increased the interest in electronic precipitation for steel mill service. The Electro-Cell washable type electric precipitator has proved extremely satisfactory for steel mill applications. Dust, soot and smoke are removed from the air with the highest efficiency. Design featuring removal collector plates offers a choice of maintenance methods—removing cells for servicing in special cleaning tank, manual washing and re-oiling in place or automatic cleaning in place without interruption of operation. Other features such as sectional construction and full-height hinged ionizers make for simplified installation and greater safety.

Whatever your motor cooling requirements, there's an AAF Filter of a type and capacity to meet your needs. Write for complete catalog data on the Electro-Cell and other AAF electronic filters.

AMERICAN AIR FILTER COMPANY, INC.
302 Central Ave., Louisville 8, Ky.
In Canada: Darling Bros. Ltd., Montreal, P. Q.

®AAF

AIR FILTERS
AND DUST CONTROL EQUIPMENT

joined Selas as manager of the dehydrator division.

Selas, well-known manufacturer of process equipment, will be able to augment its activity by this move and will be in a position to conduct related research. Design, production, sales and service will be offered by Selas.

Silica gel dehydrators are widely used wherever removal of water vapor from compressed air and other gases is of operational importance.

SPECTROGRAPHIC SERVICE OFFERED IN PITTSBURGH

▲ Spectrochemical Laboratories, Inc., is a new Pittsburgh company, offering complete spectrographic and wet chemical analysis service to producers of steel, aluminum, magnesium, bronze, ceramic materials and industrial chemicals. The laboratories and offices are located in the First National Bank Bldg., 1010 Wood St., Wilkinsburg, Pa.

The purpose of the company is to make spectrographic analyses available quickly and accurately to industrial firms that do not have their own spectrographic laboratories. It is the first company in Pittsburgh to offer such a service.

Eugene M. DuBois is president and chief spectrographer of the company. Mr. DuBois was formerly laboratory director of Orefraction, Inc.

INCO LICENSES DUCTILE CAST IRON AGENCIES

▲ Ductile cast iron, a new engineering material developed by the International Nickel Co., is now being produced by numerous foundries throughout the United States. Some of the companies licensed under pending patent applications to produce this new material are:

Albion Malleable Iron Co., Albion, Mich.; The Anstice Co., Inc., Rochester, N. Y.; Atlas Foundry Co., Irvington, N. J.; Benton Harbor Malleable Industries, Benton Harbor, Mich,; Bison Casting, Inc., Buffalo, N. Y.; Chambersburg Engineering Co., Chambersburg, Pa.; Cooper-Bessemer Corp., Grove City, Pa.; Dostal-Per Mold Foundry Co., Pontiac, Mich.; Francis & Nygren Foundry Co., Chicago, Ill.; Kutztown Foundry & Machine Co., Kutztown, Pa.; Lynchburg

Foundry Co., Radford, Va.; Motor Castings Co., Milwaukee, Wis.

Noblesville Casting Co., Noblesville, Ind.; Pitz Foundry, Inc., Brooklyn, N. Y.; Prospect Foundry, Minneapolis, Minn.; Ritter Co., Inc., Rochester, N. Y.; Sacks-Barlow Foundries, Inc., Newark, N. J.; James Spence Iron Foundry, Jersey City, N. J.; Sterling Foundry Co., Wellington, Ohio; Straight Line Foundry & Machine Co., Syracuse, N. Y.; Texas Foundries, Inc., Lufkin, Tex.; Treadwell Engineering Co., Easton, Pa.; and Youngstown Foundry & Machine Co., Youngstown, Ohio.

The new material combines the process advantages of gray cast iron, such as fluidity, castability and machinability, with the product advantages of cast steel and is characterized by a graphite structure in the form of spheroids. Its excellent mechanical properties, particularly high elastic modulus, high yield strength and ductility, have suggested many potential applications for this ductile cast iron in various industries.

75-YEAR OLD BRIDGE STILL IN SERVICE

▲ Numerous examples of steel's longevity may be seen in the bridges of the United States, American Iron and Steel Institute announced recently. The Eads Bridge at St. Louis is 75 years old with all its original 2390 tons of steel and two-thirds of its original 3150 tons of iron still in service. New York has the Brooklyn Bridge. And many other states have spans of lesser sizes which are still giving full measure of service.

In Virginia, for example, the longevity of bridges is well known. When traffic on a route increases so greatly that old spans can no longer support it, the commonwealth relocates them on lighter travelled routes.

The bridge at Lowman's Ferry, Va., is 1416 ft long, is made of a number of sturdy spans which had been accumulated from various locations in the state. One of the structures was built in 1890, another in 1908, and the remainder in later years. The central span was once a swing bridge.

Each of the veterans was match-marked, taken apart piece by piece, transported to the new site, re-erected, and given severe tests.

KAISER CO. LOCATES 30 MILLION TONS OF ORE

▲ Extensive drilling tests have proved a potential new source of more than 30,000,000 tons of high grade coking coal in the rich mining areas of central Utah, it was revealed recently by Kaiser Co., Inc.

Studies of facilities have already begun looking towards opening and operating the new coal properties to supply coking coal for the expansion of the Henry J. Kaiser steel plant at Fontana, Calif.

The new coal deposits lie in 2560 acres of land which Kaiser Co. last year leased from the U. S. Department of Interior, some 24 miles east of the town of Price, Utah. The tests disclosed coal seams from 11 to 14 ft, thus insuring low mining costs.

In addition Kaiser was recently granted a lease by the state of Utah on 480 acres of coal lands in the vicinity of the larger property, making the total acreage 3040.

The newly proven deposit is located in the famous Book Cliffs field which already supplies the vast coking coal requirements of the iron and steel plants at Fontana, Calif.; Ironton and Geneva, Utah.

Prior to opening the new mine,

For Improved Drawing and Longer Die Life

Copper-coat WIRE, ROD and TUBING *with*

Cuprodine®

"Cuprodine", in a simple chemical process without current, deposits an adherent layer of copper on both mild and stainless steels. This layer acts as an effective lubricant—reduces wear and scratching of dies; prolongs die life; minimizes scratching on wire, rod and tubing; and increases the number of draws per die.

CHEMICALS ACP PROCESSES

RUST PROOFING AND PAINT BONDING
Granodine *
Duridine *
Alodine *
Lithoform *
Thermoil-Granodine *

RUST REMOVING AND PREVENTING
Deoxidine *
Peroline *

PICKLING ACID INHIBITORS
Rodine * ®

"Cuprotek"® passivates Cuprodized and other cuprous surfaces, and acts as a paint bond, or a good temporary preventive of corrosion.

Write or call Ambler 0486, for further information on both "Cuprodine" and "Cuprotek".

Pioneering Research and Development Since 1914

AMERICAN CHEMICAL PAINT COMPANY

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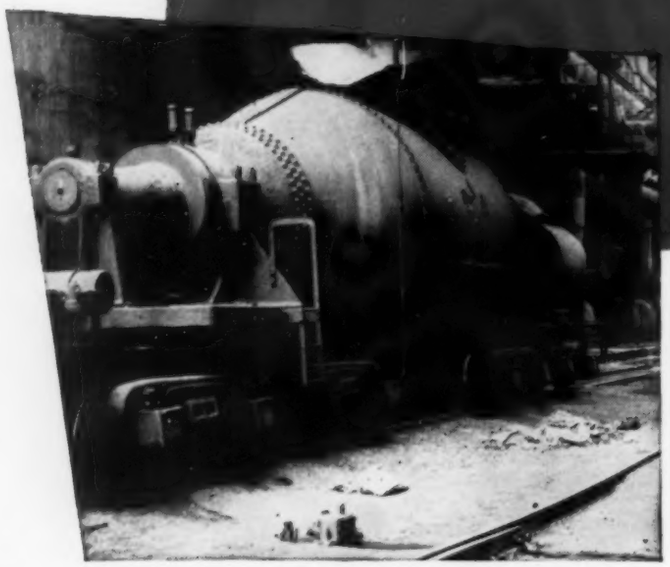
Manufacturers of Metallurgical, Agricultural and Pharmaceutical Chemicals

● Another example of TASIL Refractories *in action!*

Taylor Sillimanite means Longer Lasting Ladle Linings for



MAXIMUM Production MINIMUM Downtime

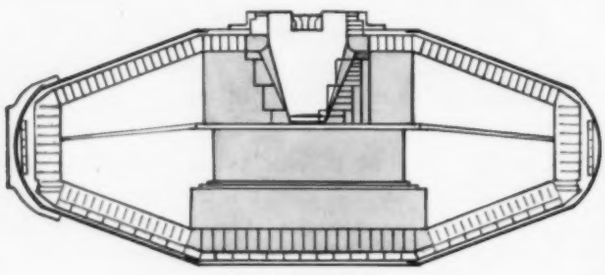
TASIL Brick and Cement are used in leading steel mills to re-enforce areas in the refractory lining which are subject to early failure due to the splash and washing action of molten iron in charging and tapping. Ladles or hot metal cars which are "Balanced" with TASIL super-refractories . . .

- **Stay in service longer**
- **Require less refractory maintenance**
- **Save on masonry hours**
- **Handle increased tonnage of iron between repairs**

TASIL brick are volume stable, free from shrinkage and are more resistant to slagging than the best grades of first-quality or super-duty fire brick, at service temperatures. Available in all standard 9", 12", 13½" and 18" sizes, power pressed.

TASIL Cements have been developed which will prevent joint erosion, making tight, weld-like joints in linings made of blast furnace quality or super-duty brick linings. Three types of air or heat-setting, wet or dry TASIL Cements are supplied. They are outstanding for high refractoriness, negligible shrinkage in service at high temperatures and resistance to slagging and abrasion. Average tonnage of iron carried in Treadwell ladles lined with super-duty fire brick, bonded with TASIL No. 301 Air-Setting Cement, has been increased from 30 to 40% in mills where performance records are watched carefully.

Let the Taylor field engineer in your district show you where and how TASIL super-refractories may be used in ladles, hot metal cars and mixers to increase production, keep equipment in service and reduce refractory costs.



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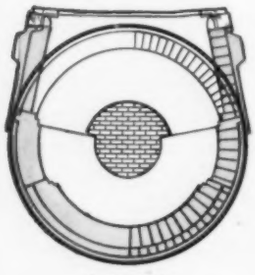


Section On ℄

● **Treadwell Ladle Lining balanced with TASIL Brick and No. 301 Cement. TASIL shown in red.**

Exclusive Agents in Canada:
REFRACTORIES ENGINEERING AND SUPPLIES, LTD.
Hamilton and Montreal

Refractorers to industry since 1864.

The CHAS. TAYLOR SONS Co

MANUFACTURERS OF REFRACTORIES • CINCINNATI • OHIO • U.S.A.

shipments will continue to be made from the existing Kaiser leased mine in the same district. The high quality of coking coal from this new deposit has already been proven at the Fontana plant, the company stated.

The additional supply of coking coal is planned in connection with the second blast furnace and 45 additional by-products coke ovens under construction at Fontana. These facilities are part of a $35,000,000 expansion program at the Fontana plant which will include a new hot rolled strip mill and a new electric weld pipe mill.

It was estimated that the new 30,000,000 ton coking coal reserve in Utah could supply the two blast furnaces at Fontana for 40 years.

TECHNICIANS ADVANCE STEEL PRODUCTION

▲ Steel production, which attained a record of nearly 92,500,000 tons in the year ending May 31, has been benefiting from gains made by managers and technicians in their long struggle to solve raw materials problems and to improve the efficiency of plants and processes, says American Iron and Steel Institute in a summary of technical accomplishments.

The quality of coking coals has been improved through installation of washing plants, thereby improving the quality of coke for blast furnaces. Mechanized coal mining had increased this problem because it is less selective of coal than hand labor. Iron ore has been made more readily usable by increased beneficiation or concentration of its iron content. This is particularly important for lean ores. The quality of scrap has improved and some other raw materials are in better supply. Strides have been made toward removing excess sulphur and silicon from molten pig iron, one of the raw materials used in steelmaking furnaces.

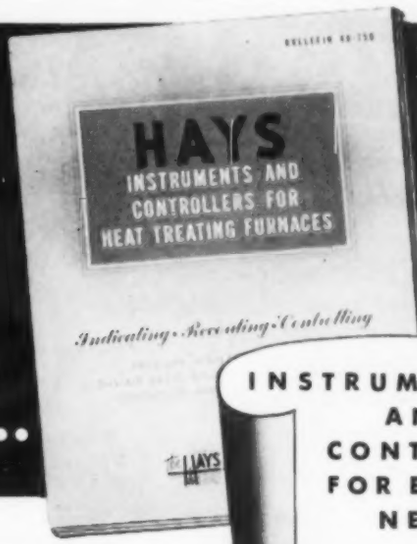
Much research work remains to be done on such problems but the fact stands out that in recent years the quality of steel has been maintained and improved in spite of less desirable quality of the basic raw materials for steel.

Output has been increased sharply through the benefits of larger furnaces, new and faster rolling mills, and improved facilities for charging furnaces so as to cut the time for this operation. The wider use of instruments affords better control over processes.

PITTSBURGH STEEL IS CONVERTING TO DIESELS

One of three General Electric 80-ton diesel-electric locomotives at the Monessen, Pa. plant of Pittsburgh Steel Co. Working 24 hours a day, seven days a week, the units handle an average of 10,000 cars a month over 50 miles of intra-plant track. Fueling takes 15 minutes every other day; oil is changed every 80 hours, taking two hours each time; and routine monthly inspections take about eight hours each, leaving the units available for work more than 96 per cent of the time.

HAYS CAN SHOW YOU HOW...



TO IMPROVE PRACTICALLY ANY PHASE OF STEEL PROCESSING, TO CUT FUEL AND LABOR COSTS

The bulletin illustrated is not just a piece of sales literature but a complete 24 page treatise on the instrumentation and automatic control of steel making and heat treating furnaces. You'll want a copy for your reference files, want to profit from its practical, authoritative information.

And remember as you read it, Hays engineers are thoroughly qualified and ready to work hand-in-hand with you in solving your own specific instrumentation and control problems . . . without obligation.

Write for your copy today . . . Ask for Bulletin No. 48-750 (covering heat-treating furnaces). Companion edition covering open-hearth furnaces will also be included.

INSTRUMENTS AND CONTROLS FOR EVERY NEED

Steel that's better, with more uniform grain structure . . . maximum production because of continuous equipment performance . . . fewer rejects . . . lower fuel, maintenance and labor costs—these are advantages you can count on when you use Hays instruments and controls for:

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At Low Cost . . .

There is an inexhaustible supply of oxygen in the air, and with Air Products generators you can extract your own oxygen from air, with no investment for equipment.

You remove the risk of delivery failures. You also eliminate loss from evaporation, residual loss and the expense of handling and delivery when you generate your own oxygen with Air Products generators.

If you use over 200,000 cubic feet of oxygen per month, it will pay you to investigate the leasing of Air Products generators. Write today, telling us your average monthly and peak oxygen loads and other pertinent information. No obligation to you.

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Assure Your Supply at low cost with
Air Products
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METAL MAKERS GROUP ANNOUNCES OFFICERS

▲ At the annual June meeting of the Electric Metal Makers Guild, Inc., the following officers were elected for the coming year: president: F. O. Lemmon, superintendent of melting, Ohio Steel Foundry Co.; vice president: E. J. Chelius, Superintendent of melting, Duquesne works, Carnegie-Illinois Steel Corp.; secretary-treasurer: R. J. McCurdy, superintendent of melting, South Chicago works, Republic Steel Corp.

JOY MFG. CO. ACQUIRES MINES EQUIPMENT CO.

▲ Joy Manufacturing Co. acquired Mines Equipment Co., St. Louis, Mo., manufacturers of mine and factory power distribution systems, it was announced recently.

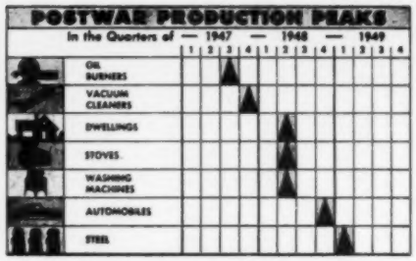
Approximately 26,800 shares of Joy stock will be exchanged for all the capital stock of Mines Equipment Co. Joy has been exclusive sales agent for several years.

POSTWAR FORECASTERS PROVEN ERRONEOUS

▲ Even the lowest of several widely circulated forecasts of postwar markets for consumers' durable goods has not been attained on an average annual postwar basis, said American Iron and Steel Institute. This is particularly true in dwelling units, passenger automobiles and refrigerators.

The year 1948, however, was far above the postwar average in output of most consumer durables. After nearly four years of peace, the ownership of homes, automobiles and household appliances is wider than ever before in the United States. The standard of living has been increased substantially. Thus, some of the wartime forecasts of postwar markets have come true but others have proved too high.

New production records have been made in this postwar period in nearly every class of household appliance, and the best previous records have been closely approached in output of automobiles and construction of dwelling units. Forecasters who came out with fantastically high figures



weren't the only ones later shown to have been unrealistic. Many experts looked for extensive unemployment and deflation immediately after the war and continuing for some time.

All the forecasts were thrown off by widespread strikes in 1946 which reduced industrial activity, particularly in steel, by shortages of scrap and difficulties in other raw materials. Gradually, these hinderances were overcome, and larger amounts of steel have been available for all uses than ever before. In the first four months of 1949 shipments of steel products were over 23.2 million net tons, an increase of nearly 2 million tons over the corresponding 1948 period. In all of last year shipments had set a new high at 65,973,000 tons.

FASTENERS GROUP SELECT NEW NAME

▲ The American Institute of Bolt, Nut and Rivet Manufacturers has officially changed its name to the Industrial Fasteners Institute. Hampered by a cumbersome and not fully descriptive name since the Institute's formation in 1931, the new name was effective July 1. The name change in no way affects the present organization and offices will remain at 1550 Hanna Bldg. in Cleveland, Ohio.

REPUBLIC TO BUILD NEW COKE OVENS

▲ Republic Steel Corp. has awarded Koppers Co., Inc., a contract for the construction of a new battery of by-product coke ovens and material handling facilities at its Youngstown, Ohio, plant, it was announced jointly by the two companies recently.

A battery of 65 Koppers ovens to replace the present No. 2 battery at Youngstown, as well as major additions to the coal and coke handling system, are included in the project.

The 65-oven battery, expected to be in operation by mid-1950, will be

capable of carbonizing 1505 tons of coal per day.

The ovens will be underfired with coke oven gas and will be equipped with Koppers self-sealing doors.

STEEL INDUSTRY NOW LARGEST POWER USER

▲ Conversion from steam to electric power, now almost complete, has made the iron and steel industry the second largest industrial user of electricity. It is exceeded only by chemical manufacture, according to the American Iron and Steel Institute. However, the operation of giant mill motors and electric furnaces was restricted at times during 1948 in order to ease the drain on public power lines during peak loads in certain areas.

The importance of electricity in the production of steel is also indicated by the size of some of the steel plant motors, an individual motor on the main drive of a rolling mill having as much horsepower as a locomotive hauling a streamlined train.

A continuous mill turning out an average of about 150 tons of strip an hour, uses approximately 13,000 kilowatt-hours of electricity per hour, or as much electricity in about six minutes as a home uses in a year.

Many other kinds of equipment are powered electrically, including such auxiliaries as cranes, cold rolling mills and blowers. Electric furnaces also use an enormous amount of current.

Conversion of a single wide plate mill from steam to electric power, as recently announced by one company, will cost over $1,700,000 and require a year or more.

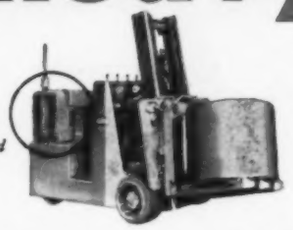
Power supply at times has been particularly tight in three steel centers, Pittsburgh, Cleveland and Chicago. They are in the midst of a great expansion program, scheduled to continue at least three years.

MINNEAPOLIS-HONEYWELL BUYS H. BELFIELD CO.

▲ Minneapolis-Honeywell Regulator Co. has announced that it has entered an agreement for the acquisition of the H. Belfield Co., manufacturers of control valves. The new acquisition

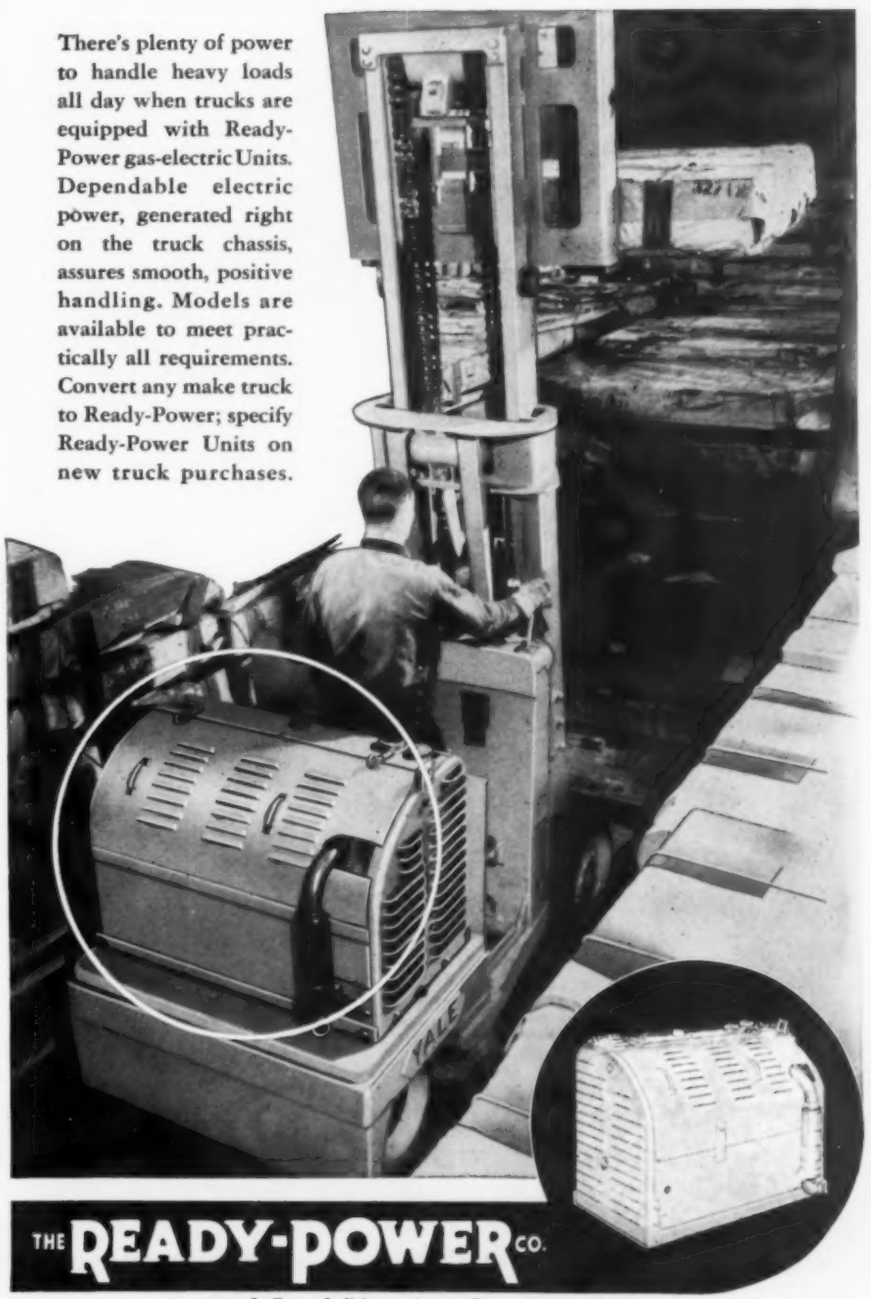
(*Please turn to page 114*)

heavy loads need READY-POWER



Ready-Power-equipped Baker truck

There's plenty of power to handle heavy loads all day when trucks are equipped with Ready-Power gas-electric Units. Dependable electric power, generated right on the truck chassis, assures smooth, positive handling. Models are available to meet practically all requirements. Convert any make truck to Ready-Power; specify Ready-Power Units on new truck purchases.



THE READY-POWER CO.

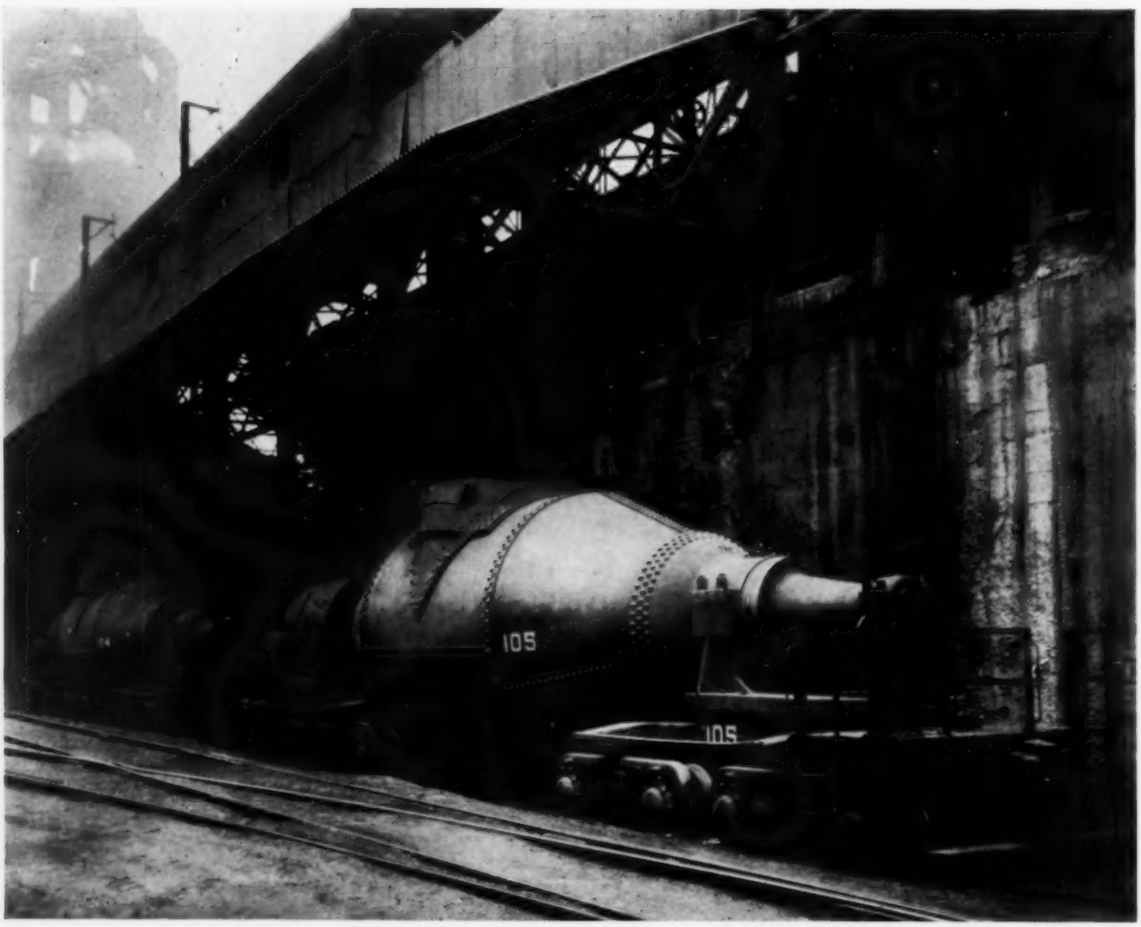
3836 Grand River Ave., Detroit 8, Michigan

TREADWELL

MIXER TYPE HOT METAL CARS

REDUCE

OPERATING COSTS



BUILT IN CAPACITIES TO MEET YOUR REQUIREMENTS

75 to 210 Net Tons

279 OF THESE CARS NOW SERVE THE STEEL INDUSTRY

M. H. TREADWELL CO., INC.

208 S. LA SALLE ST.
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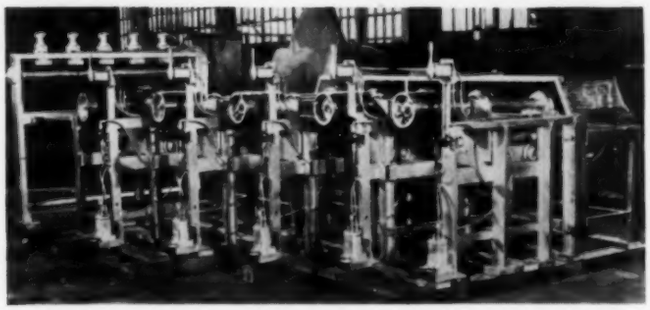
140 CEDAR STREET
NEW YORK 6, N. Y.

1217 FARMERS BANK BLDG.
PITTSBURGH 22, PA.

ROCKWELL STRIP COILING MACHINE SPEEDS OUTPUT



Individual strip coiling stations are stopped for loading and unloading by a pneumatically operated disengaging drive clutch synchronized with a braking mechanism. Finished coil is recovered by pneumatically operated stripper plate and buggy on each station. To permit removal of coils, mandrels are self-collapsing by snap action operating on spring loaded cam principle. Varying pressure on clutch plate controls winding tension of coils to prevent clutch overloading. The entire machine is driven from one common power line through chain and sprockets which drive individual heavy duty slip clutches.

This machine enables 2 men to do 2 to 3 times the work done with conventional strip coilers. Write for detailed information.

Rockwell also builds batch and continuous furnaces, coil boxes, coilers, strip stitchers, pickling tanks and machines, dryers, ovens and special equipment.

ROCKWELL SINCE 1888 BUILT

W. S. ROCKWELL CO.

FURNACES · OVENS · MACHINERY

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Copper Coolers
Copper High Conductivity, Abrasion and Wear Resistant Electrodes
Copper Hot Blast Valves and Seats
Copper Monkeys
Copper Plates—Bosh and Mantle
Copper Tuyeres—Standard and Patented
Bronze Heavy Mill Castings

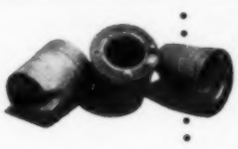
ARE *Good* CASTINGS . . .

Plus THAT "SOMETHING EXTRA"

THEY ARE PRODUCED by a skilled personnel, sensitive to your desires, working in an environment of enthusiasm and teamwork. Falcon's personnel is adaptable, flexible, highly integrated and coordinated and adequately supported with the most modern equipment and methods, and supplied with the best of metals.

Another "SOMETHING EXTRA" is provided in Falcon's PROMPT DELIVERY. Dependable for 59 years.

"Something Extra" in prompt telephone service—
Three New Trunk Lines—Call 3-4186



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Link YOUR BRUSH PROBLEM TO

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MORGANITE CARBON BRUSHES

MORGANITE engineering service — backed by years of specialized experience in motor and generator brush manufacture and application — assures competent, practical collaboration in solving any brush problem. For prompt help in the selection of the proper brush for your needs, or for quotations on brushes to your specifications, call or write MORGANITE.

Morganite INCORPORATED

LONG ISLAND CITY 1, NEW YORK

Manufacturers of Morganite Self-Lubricating Carbon Specialties including Seals, Rings, Valves, Slides, Bearings, etc., and Carbon Piles

(*Continued from Page 111*)
will be known as the Belfield valve division of Minneapolis-Honeywell.

The Belfield company, occupying a five-story building in Philadelphia, manufactures certain types of automatic control valves not previously made by the Honeywell company.

Founded in 1836, the Belfield company has pioneered in the design of valves for the railroad, coal, gas, oil and chemical industries as each has risen to prominence over the last 113 years. It is one of several nationally recognized manufacturers of regulating valves which generally are associated with control systems operating automatically from signals supplied by thermostats and other control devices.

MINE SAFETY BUILDS RESEARCH LABORATORY

▲ Research and development of safety equipment for all industries will be undertaken in a new laboratory, the largest of its kind in the world, to be built in Pittsburgh by Mine Safety Appliances Co. George H. Deike, president of the company, has just announced plans for the construction of a four-story laboratory building which is expected to be completed in September.

Facilities of the laboratory will be made available to all industry for the investigation of safety equipment problems affecting health and property, Mr. Deike explained. Activities of scientists there will be coordinated with those of the U. S. Bureau of Mines, U. S. Public Health Service, Industrial Hygiene Foundation of Mellon Institute, Harvard School of Public Health, the new School of Public Health at the University of Pittsburgh and fellowships at other leading universities.

Research and development efforts will be concentrated on instruments, equipment and other devices to safeguard the health and welfare of workers in all types of industry and, in some instances, the public generally.

Due to the increasing number of changes in industrial processes and operations, new hazards must be overcome by the development of different types of equipment, Mr. Deike pointed out. This, plus a continuing research program to improve existing equipment, will be the primary objective of the new laboratory.

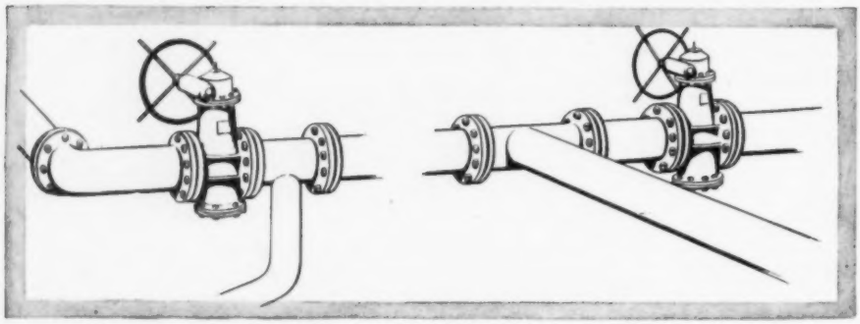
The building, to be located one block from the company's Pittsburgh plant, will be dedicated as a memorial to John T. Ryan who, with Mr. Deike, founded Mine Safety Appliances Co. here 35 years ago. It will be known as the John T. Ryan Memorial Laboratory. Mr. Ryan, an international pioneer in the field of safety, especially for mines, died in 1941.

WAGNER BUYS PLANT IN MT. VERNON, ILL.

▲ A plant consisting of industrial buildings containing 90,000 sq ft located on an eight acre tract at Mt. Vernon, Ill., has been purchased by Wagner Electric Corp.

The company is concentrating its facilities for building transformer tanks at the new plant, which is equipped with cranes capable of handling large, heavy items, and which is served by three railroad spurs.

No... Your WATER SUPPLY LINES are not actually broken this way



Loss of carrying capacity in water supply systems is costing YOU many dollars every year.

The need for additional pumps in many cases is due to friction loss — leakage — obsolescence — incrustation — unrecorded take-off — increased demand — all of which cause this costly loss of carrying capacity.

Data collected by research groups over the past ten years is so accurate that, given the source of water supply and the age of the pipe, a reasonably accurate estimate of loss of carrying capacity can be made without an examination.

The Pittsburgh Pipe Cleaner Company Engineering Department has specially trained hydraulic engineers to make these estimates for you. Write today.

And NOW — agents for the Gates Engineering Co., Offering expert application of the following plastic coatings to reduce corrosion: GACO-NEOPRENE — GACO-NEOFLEX — GACO-NITRO-COTE — GACO-DURA-FILM — GACO-"316."

PITTSBURGH PIPE CLEANER CO.
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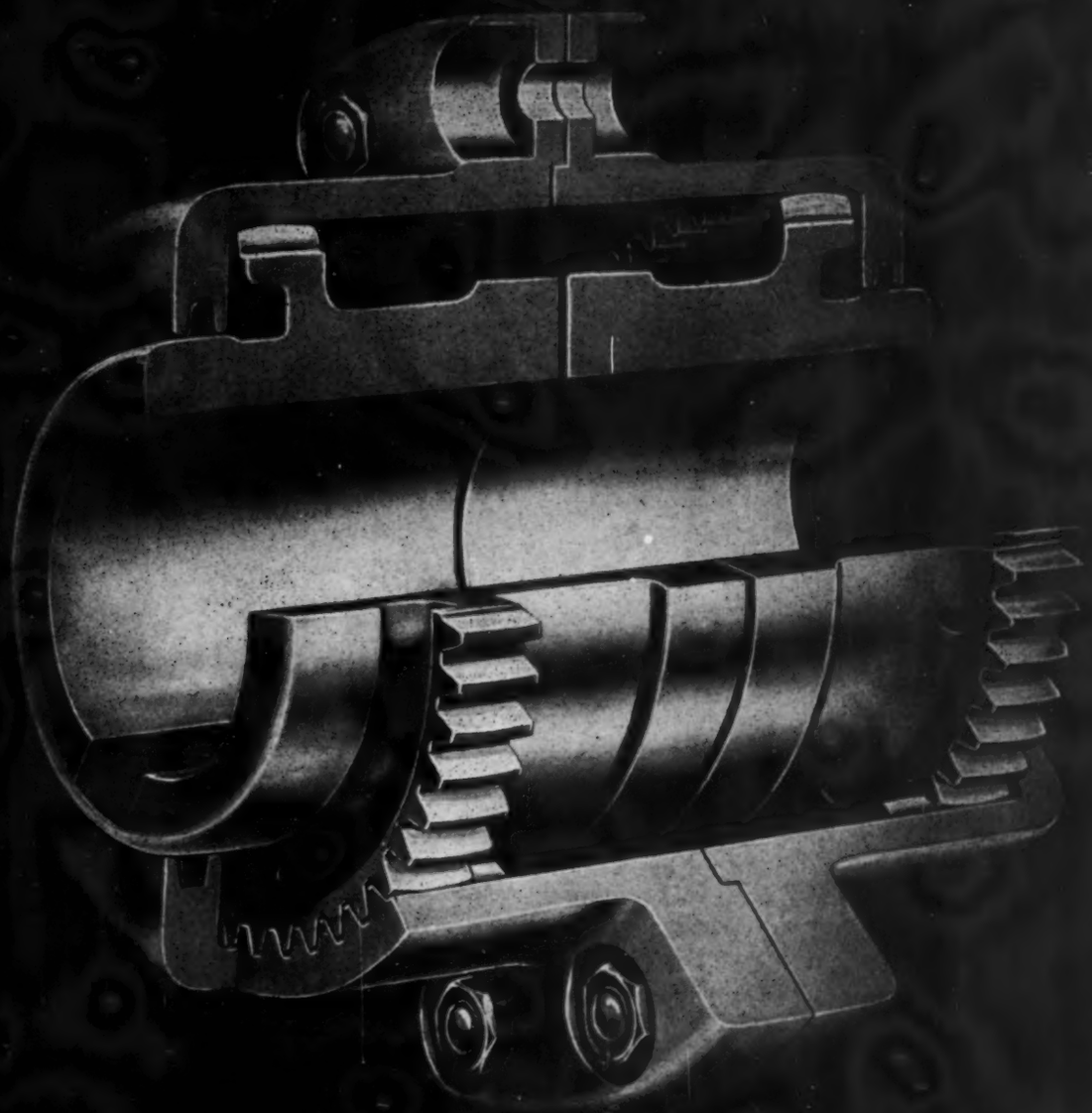
BALTIMORE • BIRMINGHAM • BOSTON • BRADENTON, FLORIDA • BUFFALO • CHARLOTTE
CHICAGO • CINCINNATI • DETROIT • HOUSTON • NEW YORK • PHILADELPHIA • ST. LOUIS

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

2 great magnet wires from a single source

TO FILL EVERY WINDING NEED

To provide a full range of sizes, shapes, and insulations . . . for a wide variety of applications . . . General Electric offers two great names in magnet wires—Formex, for temperatures to 105 C; and Deltabeston, for temperatures to 125 C.

Formex is a tough, workable magnet wire—insulated with synthetic resin — that is famous for speedy winding and extremely long operating life. Chemical-resistant, heat-shock-resistant, abrasion-resistant, small-diameter Formex magnet wires are available in all common sizes and shapes.

Deltabeston magnet wires, insulated with glass or with asbestos, are high-heat magnet wires that permit operation at temperatures higher than those allowable for ordinary cotton- or enamel-insulated wires. Deltabeston magnet wires are available in all the usual sizes and shapes.

Contact your G-E construction materials representative or distributor for detailed information about this complete magnet wire line. For the latest booklet on General Electric magnet wires, write to Section W40-746 Construction Materials Department, General Electric Company, Bridgeport 2, Connecticut.

GENERAL ELECTRIC

Ol' Red Wabbler says:

Funny thing about rolls...they ain't like people when it comes to coolin' off. Me, I like to get under a cold shower quick when I'm hot, but a roll needs to cool off real slow-like when it gets heated up, otherwise it's likely to fire-crack, spall, or just naturally break in two.

DON'T TURN A COLD SHOWER ON A HOT ROLL

In the interest of better care for rolls, and better rolling mill production, Ol' Red will send you copies of this message for your bulletin boards. Just write—

Ol' Red Wabbler
Mackintosh-Hemphill Co.
Pittsburgh 3, Pa.

This is the second of a series, originally printed in 1941, and repeated by request. Others in this series will appear in forthcoming issues.

MACKINTOSH-HEMPHILL CO.

PITTSBURGH AND MIDLAND, PA.

Makers of the Rolls with the Red Wabblers

OTHER MACKINTOSH-HEMPHILL PRODUCTS INCLUDE: Steel and special alloy castings . . . completely integrated strip mills . . . heavy duty engine lathes . . . the new Mackintosh-Abramsen straighteners . . . improved Johnston patented corrugated cinder pots and slag handling equipment . . . shape straighteners . . . shears . . . levellers.

Personnel News...

Hubert C. Smith, Great Lakes Steel Corp. chief metallurgist, was named assistant vice president in charge of metallurgical control. The new assistant vice president went to Great Lakes Steel in 1936, and was appointed chief metallurgist in 1943. He formerly had served in that capacity for the Otis works of Jones and Laughlin Steel Corp., Cleveland, Ohio.

J. L. McDermott has been appointed manager of the Ryertex division of Joseph T. Ryerson & Son, Inc. He succeeds **Kenneth T. MacGill** who is retiring after 32 years of service with the company. Mr. McDermott moves up from the post of western sales manager of the Ryertex division, which position he has held since January 1, 1948. He has been with the company since 1923, serving as sales representative in Cleveland and Pittsburgh, respectively, prior to taking up headquarters at Chicago last year.

F. J. Burd, will manage the newly opened sales office of Cutler-Hammer, Inc., at 504 Broadway, Gary, Ind. **H. Kolar,** formerly in the electrical engineering department of the Carnegie-Illinois Steel Corp.'s South Chicago works, will assist Mr. Burd in handling the sales work in this territory. The new sales office will be a branch of the Chicago district sales office.

Walter R. Coley, a vice president of Leeds & Northrup Co., retired June 1 after 43 years' service with the firm.

John A. Carter, former general manager, was elected president of Oakite Products, Inc., 22 Thames St., New York, N. Y., and **D. C. Ball,** founder and longtime president, was elected chairman of the board.

H. L. Smalley has been appointed assistant to the president of Harbison-Walker Refractories Co., Pittsburgh, Pa.

Robert A. Specht has been appointed manager of a new heat transfer division which National Radiator Co., Johnstown, Pa., has created to handle the design and sales of heat transfer products for the chemical, petroleum, gas and steel industries. Mr. Specht has been with National Radiator for several years as an eastern sales representative in the company's industrial division. Prior to this work he was associated with Struthers Wells Corp., Warren, Pa., as a heat transfer specialist. His headquarters will be at 60 East 42nd St., New York, N. Y.

Leo. J. Halkovich has been appointed a district representative for the construction materials department of the General Electric Co. Mr. Halkovich will serve the wholesale trading area of Johnstown and Altoona, Pa., and will make his headquarters at the former city.

William R. Kalbach is assuming new duties in sales and service engineering for Hagan Corp.'s Cincinnati district office. Mr. Kalbach has been in charge of service work in Hagan Corp.'s New York City district office since 1946.

E. H. Remde, formerly works manager of the industrial truck division of Baker-Raulang Co., Cleveland, Ohio, was advanced to the newly created post of advisor to the president on engineering and manufacturing; **H. A. Schultz,** formerly superintendent, to manufacturing engineer; **I. L. Young** to the position of general superintendent; and **John A. Matousek** was named manager of manufacturing.

H. P. "Jack" Barnes was named manager of the Plibrico Sales & Service Co. at Pittsburgh, Pa., and distributor of Plibrico refractory products. The office is located at 921 Empire Bldg.

W. M. Walker has been appointed district manager in the Cleveland area for The Torrington Co., Torrington, Conn., and South Bend, Ind. **J. N. Wholean** has been transferred from the Milwaukee office to the Cleveland office as district engineer, while **R. U. Sautter** has been transferred from the engineering department of the Bantam Bearing division of the company at South Bend to the Milwaukee office as district engineer.

HUBERT C. SMITH

J. L. McDERMOTT

F. J. BURD

H. KOLAR

The Pennsylvania Crusher Co., Philadelphia, Pa., a division of Bath Iron Works Corp., announces the appointment of **John A. Plimpton** as division manager. Mr. Plimpton succeeds **Stanley D. Hartshorn,** who has completed 25 years of service with the crusher company as sales engineer, sales manager, and, since purchase of the company by Bath Iron Works Corp., as general manager. Mr. Hartshorn will remain active in the organization as consultant on sales and engineering problems, and as independent sales agent in New York state and eastern Canada. Mr. Plimpton has been district manager of the company in New York, N. Y.

W. R. Patterson has been appointed general superintendent of the steel department at the Torrance, Calif., plant of National Supply Co. Mr. Patterson will also continue in his present capacity as chief plant metallurgist.

Harry H. Lumley, Chicago district manager of operations for American Steel & Wire Co., has been appointed assistant to the vice president of operations of the wire company, **John R. Gaut,** presently assistant manager of operations, succeeds him as Chicago district manager of operations for the U. S. Steel subsidiary. Mr. Lumley will continue to maintain his headquarters in Chicago.

Oscar N. Lindahl, vice president-finance, Carnegie-Illinois Steel Corp., retired June 30 after 42 years of service with United States Steel subsidiary companies.

Darwin S. Wolcott, vice president of Lukens Steel Co., Coatesville, Pa., retired from the company on July

LOOK TO THE FUSE LEADER FOR PRODUCTION PROGRESS

WARE HI-LAG *Renewable* FUSES

Wide Double Contact Surfaces — Spring Tension Locking of Links

Expansion and contraction of metals during *Off* and *On* periods compress links. This fluctuation causes loose contacts and oxidation in other fuses, which finally result in excessive heating and unnecessary blows. WARE HI-LAG construction keeps contacts permanently tight, thus insuring low resistance and longer fuse life.

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Amsco WELDING PRODUCTS

Amsco No. 459

Increases life 2 to 5 times for dippers, pug mill knives, brick dies, shredder knives, drag chain links, pulverizer hammers, sand pumps and similar parts. Amsco No. 459 is centrifugally cast . . . resists softening up to 800° F. . . . and has a Brinell hardness of 500-600. No. 459 produces a chrome-moly martensitic iron deposit and is designed for severe abrasion service with moderate impact conditions.

The application above shows Amsco No. 459 applied to the front and teeth of a manganese steel walking dragline bucket, used for stripping overburden from iron ore at a Minnesota mine. In similar applications where more severe impact coupled with abrasion is encountered, Amsco Economy Hardface is recommended.

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Hard Surfacing by Fusion Welding

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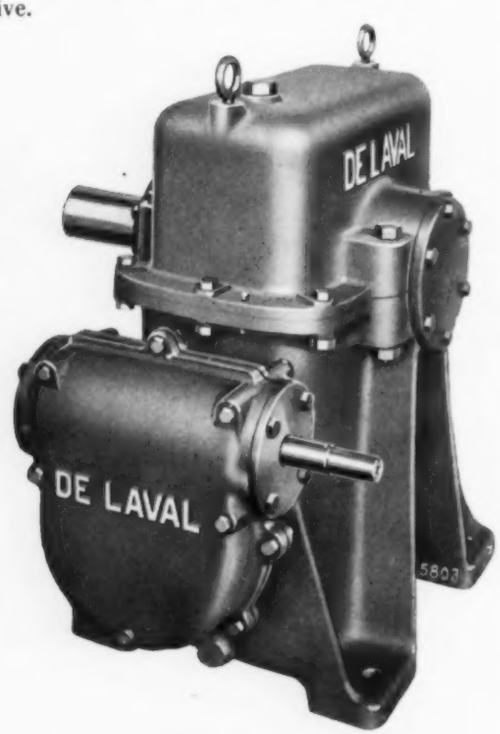
HIGH TORQUES?

DE LAVAL SPEED REDUCERS

For low final speeds Worm Gear Speed Reducers should be selected on the basis of output torque ratings.

If your problem is to select a gear reducer capable of carrying high torques, consult De Laval, either directly or through a sales representative.

ONE OF 93



This double reduction De Laval Worm Gear Speed Reducer is available with many standard gear ratios and is but one of 93 sizes and types of standard De Laval Worm Gear Speed Reducers.

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Worm Gear Division

DE LAVAL

De Laval Steam Turbine Co., Trenton 2, N. J.

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9. He joined Lukens in 1925 as assistant to the president shortly after his brother, Robert W. Wolcott was elected president of the firm. In January, 1928, he was elected a vice president, in which position he has continued to the present.

George L. Stout has established a manufacturers' agency at 528 Walnut St., Cincinnati, Ohio. The new sales agency will represent Federal Electric Products Co., O. Z. Electrical Manufacturing Co., J. R. Richards Co., S. H. Couch Co., Inc., Great Western Fuse Co., and Detroit Industrial Products Co. Mr. Stout formerly was Cincinnati district manager for Federal Electric Products Co.

Frank M. Goodman, formerly of Skilsaw, Inc., has been appointed sales promotion manager of the industrial division of Lincoln Engineering Co., St. Louis, Mo.

FRANK M. GOODMAN

Mr. Goodman will work with the industrial distributors and promote the sales of Lincoln industrial lubricating equipment.

Roger W. Batchelder has been appointed vice president in charge of sales of the National Bearing division of American Brake Shoe Co. He will continue to be located at division headquarters in St. Louis, Mo. Mr. Batchelder, formerly assistant to the president of National Bearing, has been with Brake Shoe since 1933. He was general purchasing agent of the company from 1945 to 1948.

William W. Hopwood has been elected vice president of Hagan Corp., Pittsburgh combustion and chemical engineering firm, and its subsidiaries: Calgon, Inc., Hall Laboratories, Inc., and the Buromin Co.

Robert S. Fleshiem has been promoted from manager of Allis-Chalmers electrical department to assistant to the executive vice president of the company's general machinery division. In his new post, he succeeds **J. D. Greensward,** recently named general manager of the company's Norwood, Ohio, works. **Roy M. Casper,** who has been manager of Allis-Chalmers motor and generator section, becomes manager of the company's electrical department.

D. D. Pendleton has retired from active business. In 1892, Mr. Pendleton began his career with Westinghouse Electric Corp. Since 1908, he has been a manufacturers' agent in the Pittsburgh, Pa., area for various power plant and industrial equipment manufacturers.

Gilbert Soler, formerly works manager has been

named vice president, manufacturing operations and a director, Atlas Steels Ltd., Welland, Canada. Mr. Soler has been with the company since 1946. He had previously been associated with Republic Steel Corp., and the steel division of the Timken Roller Bearing Co.

William Van C. Brandt, of Philadelphia, one of the pioneers in the battery-powered industrial truck industry, has been appointed managing director of the Electric Industrial Truck Association. Active in the EITA for the past 25 years, Mr. Brandt has resigned his position as manager of railway and motive power sales for Electric Storage Battery Co., Philadelphia, Pa., to accept the new post. He succeeds **C. F. Kells,** who left EITA to join a publishing firm. Succeeding Mr. Brandt as vice president of EITA is **M. W. Heinritz,** vice president of Gould Storage Battery Corp., Trenton, N. J.

Obituary

Hubert Merryweather, 67, retired general manager of ore properties for Bethlehem Steel Co., died suddenly June 7 at his home in Bethlehem, Pa.

William R. Timken, 84, co-founder and formerly secretary-treasurer, Timken Roller Bearing Co., Canton, Ohio, died recently.

Earl C. Souder, for 20 years an industrial sales engineer in the steel mill section at Westinghouse Electric Corp.'s East Pittsburgh plant, passed away in Baltimore, June 8. Mr. Souder has been in the continuous employ of Westinghouse since immediately following the first World War. During this time he has worked with many of the steel companies.

A Good Thing To Remember About Metal-Cleaning:

No matter what your cleaning problem — from removing slushing oil to buffing compound residues — there is an Oakite cleaning material designed for just that job. The many metals and alloys, the many fabricating and finishing processes and the countless varieties of dirts, make metal-cleaning a complicated business . . . But the Oakite Chemical Research Laboratory and Technical Service Department have had 40 years of success in solving new problems.

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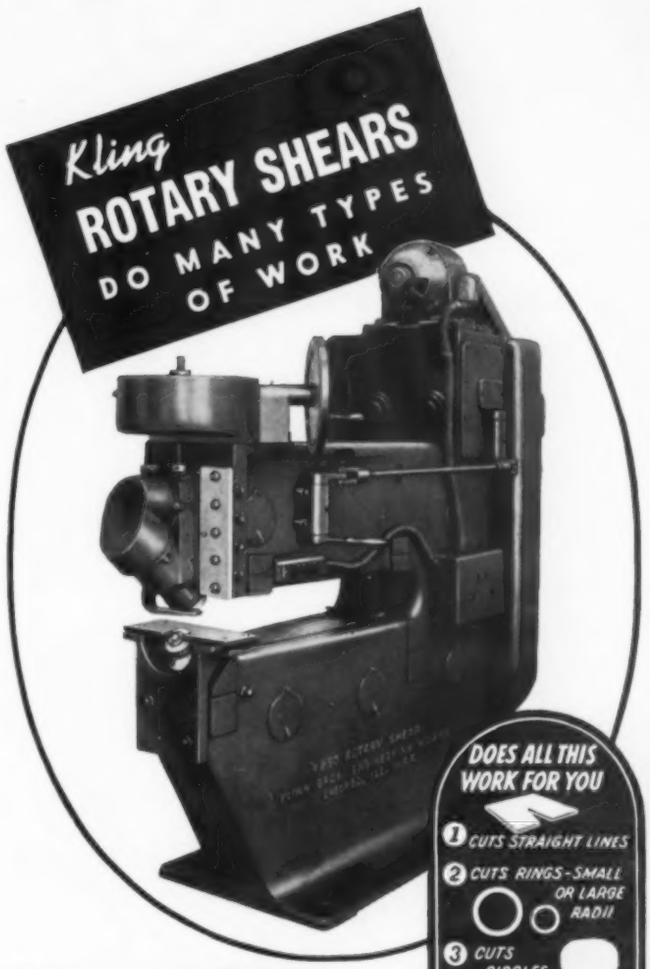
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8 BEVELS OF ANY ANGLE
9 CUTS REVERSE CURVES
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Rapid operation . . . Hairline Accuracy . . . the use of Kling Rotary Shears marks the latest development in cutting mild steel, and sheet metal, up to 1-inch with amazing savings in time, labor and production costs.

For exacting projects (see illustration at the right), no single unit of metal-working equipment does so many different things so cleanly and efficiently as does the Kling Rotary, pictured above.

In metal-working plants, automotive, aviation, home appliance, and other industries, where work of this character is being done — this machine is held in high regard for its versatility and economy of operation.

This great usefulness is the result of half-a-hundred years of engineering experience which prospective buyers, with reason and respect, applaud.

Send Today for Bulletin No. 245 which will give you specific facts, and specifications. No obligation involved. Users of heavy equipment of Kling Rotary Shears' class will receive a copy of this Bulletin promptly, on request.

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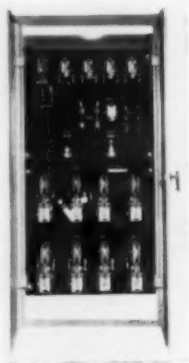
Equipment News...

GENERAL ELECTRIC ANNOUNCES NEW D-C MAGNET BRAKE AND D-C CRANE HOIST CONTROL

▲ Two closely related equipments, a new d-c two-shoe, two-magnet brake and a new d-c crane hoist control, have been announced by General Electric's control divisions. The new brake is designed for use on steel mill drives, cranes, hoists, bridges, and conveyors. The new control is specially intended for use on whirley, revolver, gantry, and overhead cranes in steel mills, on ore bridges, in warehouses, and on loading and unloading towers.

The brake consists of a malleable iron frame, two self-aligning shoes which pivot on spherical bearings, two armatures pivoting on sealed graphite bearings, two symmetrical E-type magnets with cast-in coils, and a ventilated wheel of molybdenum alloy. The iron frame fully protects all moving parts, universal ball joints protected by neoprene sleeves permit self-alinement of shoes and insure uniform lining wear, and a quick-release mechanism, which responds to a wrench, permits removal of wheel, horizontally or vertically, or changing brake linings without disassembling any part. The cast-in coils, sealed in a heat-resisting insulating compound, assure faster action, reduction of "stick-in" because of residual magnetism, protection from moisture reaction, and good heat transfer. The torque-setting indicator gives a direct reading of foot pounds torque setting and the clearly marked operating gap indicator provides a ready visual check on magnet gap and lining wear. The brake is applicable for either right- or left-hand mounting, either on the floor or, with brackets, on motors.



The new d-c crane hoist control provides power hoist- and dynamic lowering.

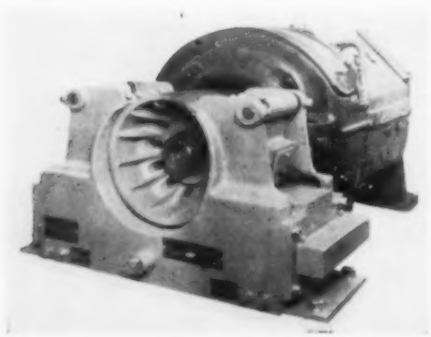
Designed throughout to operate smoothly and efficiently under the most severe conditions, the brake is easy to install, adjust, and service.

The new crane hoist control incorporates several unique features. It provides power hoisting and power dynamic lowering, depending upon the requirements of the load on the hook. The change from power to dynamic braking lowering is inherent in the control and hence is independent of either the operator or any particular control device. When decelerating the speed is reduced automatically before the solenoid brake sets, thus minimizing mechanical brake maintenance and protecting both motors and hoist equipment from excessive wear and shock.

In addition, both overshoot and down drift are eliminated. When the master switch is thrown rapidly from the off position to any lowering position, with a load on the hook, the motor speed does not overshoot; and since the first hoisting point will hold rated load with no downward drift, the master switch need only be moved to the second hoisting point to lift the load.

Furthermore, ample protection is afforded by a spring-closed contactor which provides dynamic braking circuit, thus assuring a retarded lowering speed even if the magnet brake fails to hold an excessive load. Throughout, the equipment is sturdily built to withstand wear and vibration, and a metal-clad enclosure protects the panel against dirt and dust.

The brake is designed for use on drives, cranes, hoists, bridges, and conveyors.



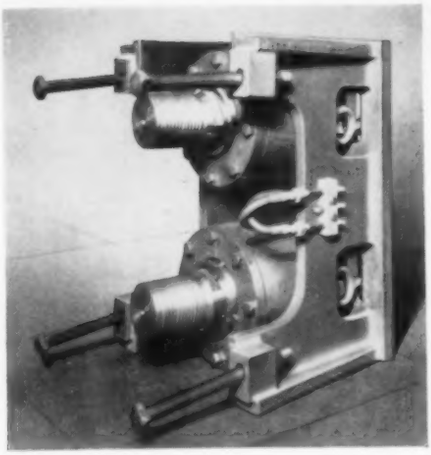
TWIN STRAINER LINE HAS NOVEL FEATURES

▲ A completely new line of twin strainers has just been announced by the accessories department of Elliott Co. They are built in sizes up to 24 in. for removing foreign matter from water, oil, and other liquids at pressures up to 125 and 250 psi.

Constructed with two strainer chambers in one body, either chamber can be shut off for removing and cleaning the strainer basket without interruption of flow. Having no moving parts except valve mechanisms, little maintenance is required. An outstanding feature is their remarkably low pressure drop, due to the "straight-line" flow and large basket area. These sturdily built strainers have cast Meehanite bodies with steel plate doors. Baskets are of hard copper mesh on rigid frames. By using carefully selected metals, electrolysis is greatly minimized.

END THRUST BEARING FOR ROD AND BAR MILLS

▲ A newly developed end-thrust bearing, designed to work with conventional plain radial bearings on rod or bar mills, is now being marketed by Mackintosh-Hemphill Co. The new thrust bearing is available as a separately-attachable unit for easy installation on any mill stand where one end of the rolls is open.



The new bearing is available for installation on any mill stand where one end of the rolls is open.

It is said by its developers to allow precision control over axial matching of roll passes, and to have many qualities attractive from an operations and production viewpoint, among which are claimed: Elimination of conventional wearing-type side thrust collars; ease and accuracy of adjustment; permanence of roll grooves location after adjustment; long service life of anti-friction bearing elements; increased life of roll grooves and guides and increased mill tonnage, better yield and more accurate tolerances.

Additionally, Mackintosh-Hemphill Co. claims important operating and maintenance economies because of reduction in electrical load on mill motor; particularly in relief of motor from high-torque starting loads.

The new bearing features a cartridge containing a double direction anti-friction thrust bearing mounted on a pin which fastens to, and rotates with, the roll. An outer casing, bolted permanently to the roll housing, encloses these roll-controlling cartridges and, by means of a simple threaded push-pull device, allows for the lengthwise adjustment of each roll and for its locking in position after groove matching.

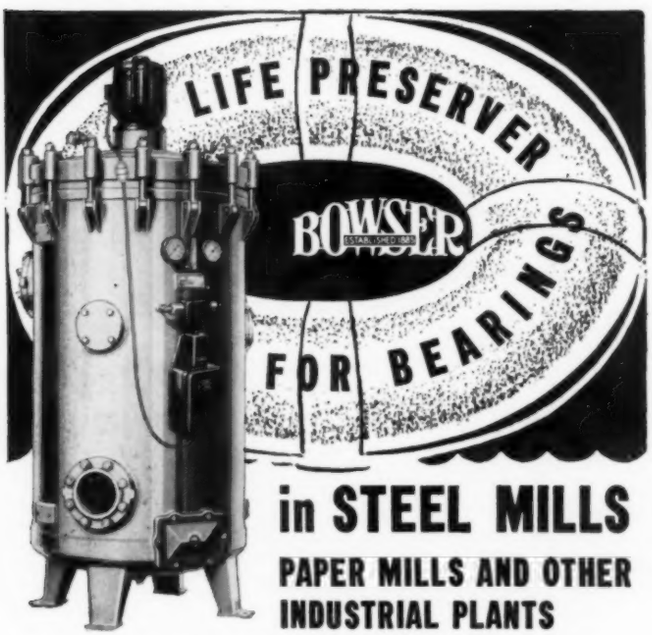
This new device is said to be especially applicable on high speed finishing stands of today's continuous rod mills, where its use in conjunction with plain water-lubricated radial bearings, will result in precise control over product tolerance.

PLUNGER VALVES FOR MANUAL OPERATION

▲ C. B. Hunt & Son, Inc., has just introduced an entire new line of small single plunger valves known as Series "O" and "OE" valves.

These valves feature the utmost simplicity in design; sturdy construction using the best materials; and extreme ease of operation. They can be operated with a minimum of effort and result in a minimum of operator fatigue. Consequently they are extremely well suited for use with manually controlled presses, pilot circuits, and in other processing cycles when frequent manual operation is required.

The valve consists of an aluminum housing; a hollow stainless steel plunger with precision placed ports; carefully dimensioned brass spacers that are accurately positioned end to end on each other (not through packing); efficient "O" ring packers; and closing brass gland nuts and an aluminum push button. The valves are balanced and will remain in posi-



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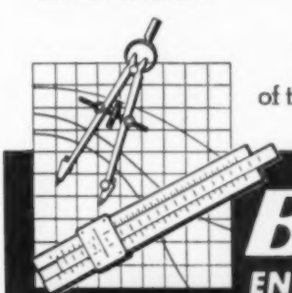

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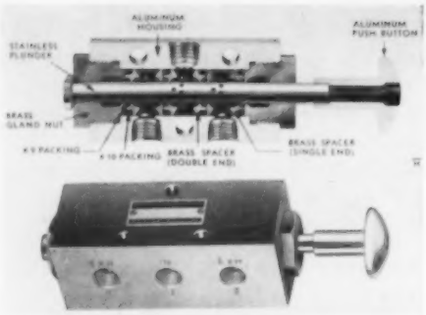


A spring can be mounted between the push button and gland nut when spring return action is desired.

tion until changed. A spring can be mounted between the push button and gland nut when spring return action is desired.

The flow is through the plunger and around the seals, (not through them), thus prolonging the life of the packing and valve parts, and reducing repairs and maintenance to a minimum. The valves can be completely disassembled for repacking, and reassembled in a few minutes without disturbing the connecting piping.

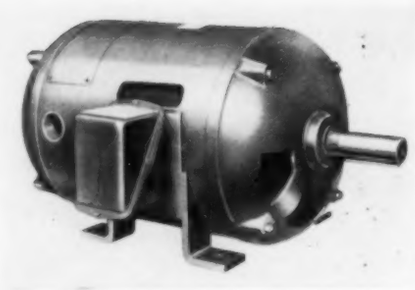
Series "O" and "OE" valves are furnished tapped for either ⅛ in. or ¼ in. pipe connection, and are available in 2-way; 3-way open exhaust 3-way piped exhaust; double 2-way; 4-way; and 5-way designs; and with either push-pull or push and spring return actions.

These valves are suited for use with air, oil or water, at pressures up to 125 psi maximum (also vacuum), at normal temperatures (not exceeding 150 F). Class "O" valves have piped exhaust. The "OE" valves have an open exhaust, and should be used with air only.

CROCKER-WHEELER BUILDS NEW DRIP PROOF MOTOR

▲ The Crocker-Wheeler Electric Mfg. Co. announces its new Form BW protected-type wound-rotor motor, built in NEMA frames 224-505 in ratings up to 100 hp, and in larger frames up to 2000 hp.

Frames and end shields are drip proof. In addition to the standard drip proof enclosure, these motors are available splashproof, and totally-enclosed non-ventilated. Other mechanical modifications include NEMA floor, sidewall, and ceiling-mounting assemblies, and NEMA C face and D flange mountings. Both C face and D flange motors are available for horizontal or vertical operation, with or without feet.



Crocker-Wheeler Protected-Type wound-rotor motors are designed for applications requiring smooth acceleration, high starting torque with low starting current, ability to start and stop or reverse frequently, or variable speed. They are suitable for driving conveyors, crushers, printing presses, fans, centrifugal compressors, etc. Special windings are available for crane and hoist service.

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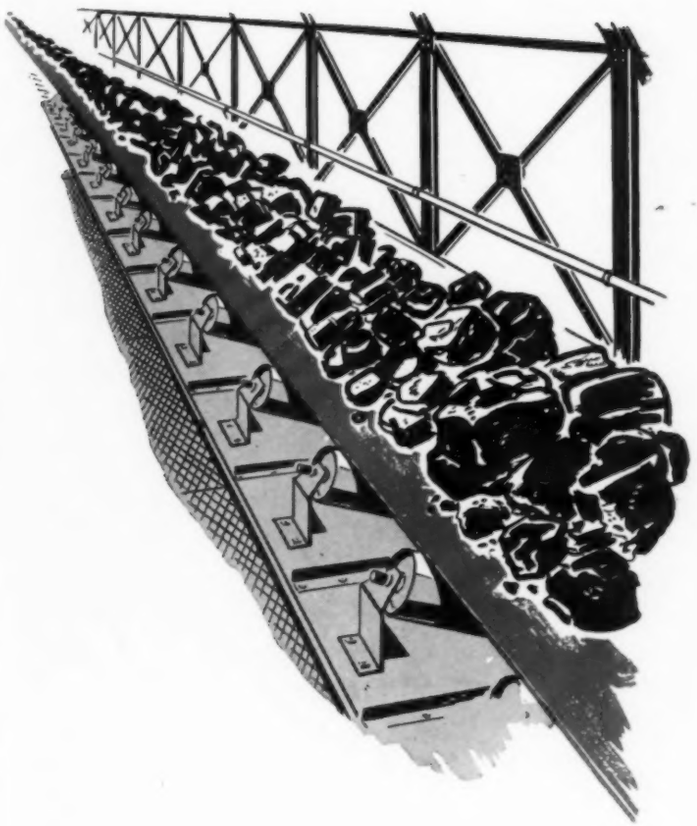

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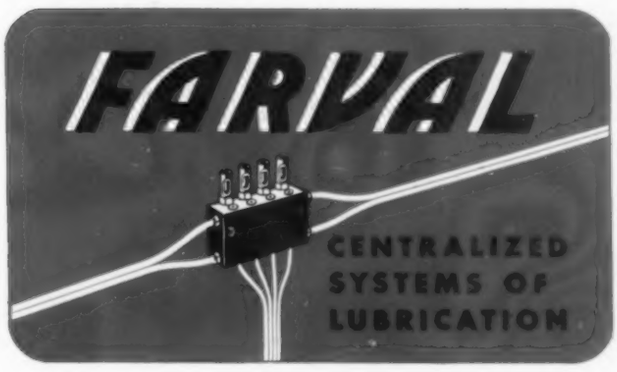

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